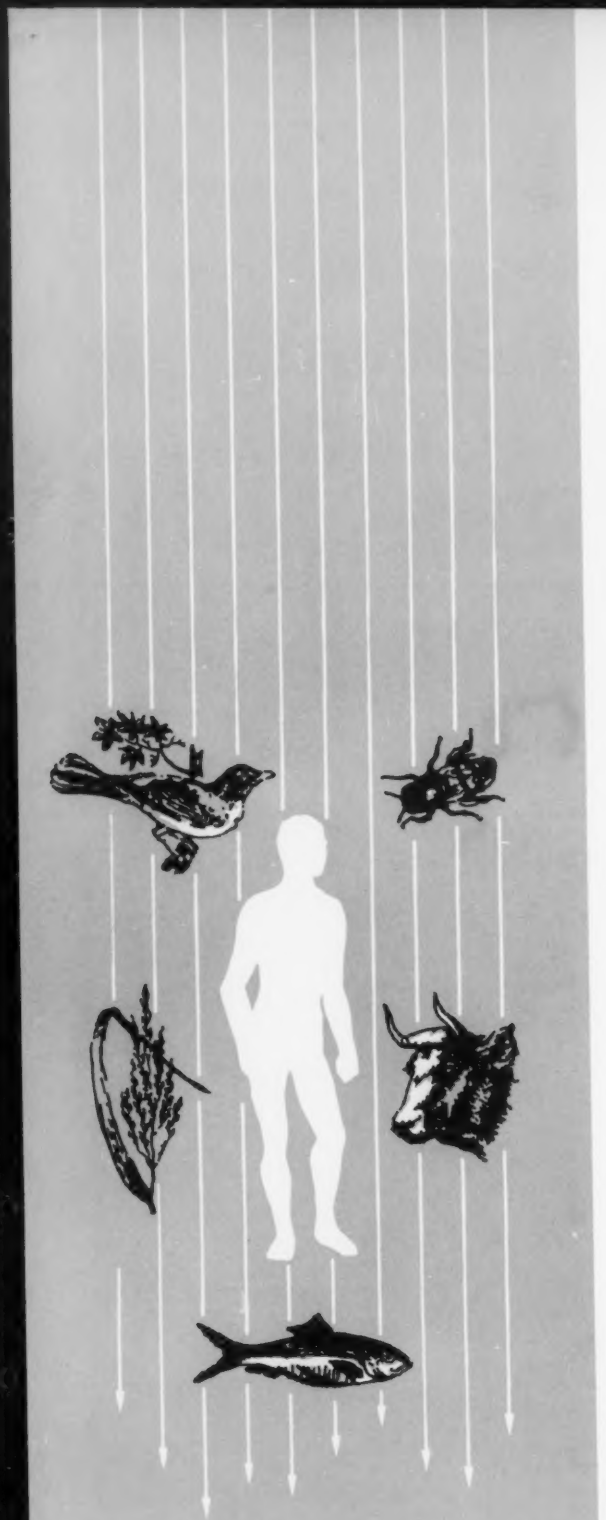

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PESTICIDES IN PEOPLE

A study of Pesticide Residues in Michigan's General Population, 1968–70 [1]

Arthur W. Bloomer, Stanley I. Nash, Harold A. Price, Robert L. Welch [2]

ABSTRACT

A study undertaken in Michigan from August 1968 to April 1970 showed that the county of residence was the most significant factor for determining pesticide residue levels in humans. Occupation, sex, and location of residence were also determined to be associated with blood residue levels. Residues of ∑DDT and dieldrin were greater in persons 45 years or older. No relationships were detected between blood hemoglobin and blood residue values. In general, as the blood levels for glucose, cholesterol, uric acid, and creatinine increased, so did the levels of pesticide residues. However, when all variables were used, no equation could be developed which would reliably predict a blood residue level given these demographic characteristics.

Introduction

General awareness of pesticide residues in living organisms, including humans, started with the discovery of residues of DDT or its metabolites in humans and other animals in the mid- to late 1940's (*7, 9, 11*). In 1968 the authors helped to initiate a study of segments of the general population in Michigan to assess the relationships of chlorinated hydrocarbon pesticide residues and such variables as blood biochemistries and demographic characteristics.

The Community Study on Pesticides (*8*) was initiated to determine effects on humans of longterm exposure to pesticides. To form as clear a picture as possible concerning the effects of pesticide exposure on humans, both individuals from the general population and individuals who had experienced definite pesticide exposures were selected for evaluation. The present study was undertaken in an effort to provide a clearer picture of pesticide exposure effects in human population.

Sampling Procedures

When the study was initiated, the Michigan Department of Public Health in cooperation with local health departments was conducting an Adult Health Screening Program. Mobile laboratory clinics were used for obtaining blood specimens and medical histories from ambulatory persons, aged 18 and older, who presented themselves voluntarily to these units for screening tests.

Analysis of laboratory capabilities and of the screening program volume indicated that a systematic sample of 1 to 20 persons would provide accurate results. An informed consent was obtained from each participant. In addition to furnishing an extra blood specimen for residue analysis, each person disclosed his/her age, sex, race, marital status, address, and occupation. The study extended from August 15, 1968, through April 7, 1970, during which time blood specimens and demographic data were collected from 1,035 persons. The cut-off date for the sample was determined by a change in analytical procedures in the laboratory which prevented comparison of subsequent pesticide residue values. The sample does not statistically represent Michigan's general population; hence inferences about the general population from these results are not necessarily appropriate.

Analytical Procedures

The following blood biochemistries were determined according to the Technicon Auto Analyzer Methodology (*12*):

Biochemical tests	*Normal Range*
Hemoglobin	Male 14–18 g/100 ml Female 12–16 g/100 ml
Glucose	80–120 mg%
Uric Acid	6.3 mg%
Creatine	1.3 mg%
Cholesterol	140–270 mg%

[1] Study supported by Food and Drug Administration, U.S. Department of Health, Education, and Welfare, Community Studies on Pesticides, under contracts PH 86–65–50 and FDA 70–19.

[2] Michigan Department of Public Health, Lansing, Mich. 48909.

Chlorinated hydrocarbon pesticide residues were determined in blood sera by electron-capture gas chromatography. A modification of the Dale, Curley, and Cueto method (*3*) was used. Two ml serum and 6 ml nanograde hexane were mixed in a 13-ml centrifuge tube at high speed on a Vortex mixer to emulsify the sample. The emulsified serum was centrifuged at 2,000 rpm for 20 minutes to produce a distinct separation of both phases. The hexane layer was transferred to a 25-ml Kuderna-Danish concentrator by means of a disposable pipette. Each sample was extracted three times. Emulsions formed easily on the second and third extractions. After a 3-mm glass bead was added and a modified micro-Snyder column was attached, the combined extracts were concentrated to approximately 1 ml on a 90°C water bath.

Final volume was adjusted to 1 ml by evaporation under a gentle stream of dry nitrogen. A 5-μl aliquot was injected into a Micro-Tek MT 200 gas chromatograph equipped with tritium foil detectors at 210°C and U-shaped glass columns (6 ft. by ¼ in. OD) at 200°C. Columns used were 1.5 percent OV-17/1.95 percent QF-1 on Chromosorb W-HP 80/100 mesh and 4 percent SE30/6 percent QF-1 on Gas-Chrom Q 80/100 mesh with nitrogen flows at 65 ml/min and 80 ml/min, respectively. All qualitative retention times were relative to that of aldrin. Quantitation of pesticide residues was based on relative peak heights. Lower limits of sensitivity for chlorinated hydrocarbon insecticides were as follows: 1.0 ppb (ng/g) for *p,p'*-DDE, dieldrin and β-BHC; 2.0 ppb for *o,p'*-DDT, *p,p'*-DDT, and *p,p'*-TDE. All values less than the sensitivity values were recorded and computed as zero.

The internal quality control program consisted of dividing a human sera composite into culture tubes and storing at −5° to −10°F. Each month controls were removed from the freezer and analyzed along with the routine samples. Results of the controls analyzed indicated the laboratory was in control and within acceptable accuracy and precision limits.

Following are statistics for 24 control sera analyzed during 1970.

	PESTICIDE RESIDUE, ppb		
	p,p'-DDE	*p,p'*-DDT	Dieldrin
Mean	50.15	10.56	1.89
S.D.	2.484	0.933	0.284
Range	45.4–53.9	9.1–12.0	1.4–2.3

Reagent blanks were routinely analyzed along with samples and did not indicate significant levels of the pesticides quantitated in the study.

The laboratory also participated in an interlaboratory quality control program. Several times a year the laboratory received blind controls from the Food and Drug Administration, Primate Research Center in Perrine, Fla. (presently Environmental Toxicology Division, Human Effects Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, N.C.).

After the Perrine Laboratory had checked and compiled the results from all participating laboratories, results and a performance critique were issued to each laboratory.

Results were confirmed by microcoulometry. Pesticide residues in individual sera could not be confirmed because levels were below the detectability limit of this instrument. Therefore, pooled specimen extracts greater than 50 in number were collected for confirmation. Residues of *p,p'*-DDT, *p,p'*-DDE, and dieldrin were confirmed in the pools tested.

Demographic Data Collection

Occupations of individuals sampled were placed in one of three categories: possibly pesticide related, not related to pesticides, and unknown. Farmers and foresters were placed in the first category because the use of pesticides is not implicit for these occupations but there is a strong probability that the subjects have some association with them. Housewives, school teachers, machinists, mechanics, clerks, bankers, and other occupations were descriptive enough to place in the second category. Persons who were self-employed, retired, or unemployed were placed in the third category.

Location of residence was determined by mailing address to fit one of three categories: rural, urban, or unknown. If the mailing address was listed as a rural route, the participant was categorized rural. Residents who had not given a complete address were placed in the unknown category.

Even though information on race was obtained, authors did not use it during analysis of data because fewer than 1 percent of the persons sampled were Negro; all others were Caucasian. Race was excluded as a variable for subsequent analyses.

Several different statistical techniques were employed for analyzing data. Most of the intergroup comparisons used a one-way analysis of variance to test the null hypothesis. If an analysis of variance test was significant, then multiple comparison tests were computed to determine the important means. Linear regression analysis was used in an attempt to detect any linear relationships in the data. Multiple linear regression was used with many of the nonresidue variables as the independent variables and with specific residue variables as the dependent variable in an attempt to explain the sample variance and define an overall predictive equation. In several cases a log transformation was performed on the data prior to the statistical tests to stabilize the variance.

Concerning the levels of statistical significance: small differences can be statistically significant when large samples are involved. These differences may or may not be medically significant. In the present study alpha levels were determined in relation to sample size in the individual statistical test. (An alpha level is defined as the probability that a person rejects the null hypothesis when it is really true, i.e., announces a difference which really does not exist.) In no case was an alpha level greater than 0.1 used. Thus when determining the statistical significance levels, authors used levels which were conservative. That is, when claiming a statistical significance for a particular comparison an alpha level was used which would reduce the probability of finding a false difference. The converse is also true: i.e., by using conservative levels, the authors may have missed some true differences.

Results and Discussion

Statistical analyses of demographic variables indicated that the sample in the present study approximated Michigan's general population as depicted in the 1970 census. Two exceptions were that the study sample had a slightly higher percentage of persons in the older group and that the percentage of males in each age group was greater than expected except for the youngest group.

As stated earlier, race was not used as a controlling variable. Furthermore, urban/rural comparisons were not possible because definitions of the present study were different from those of the Bureau of the Census, U.S. Department of Commerce.

When blood biochemistries were evaluated using both age and sex breakdowns and then compared with published values (*1,2,10,12*), the Michigan sample appeared to represent a normal population. The biochemistries evaluated were cholesterol, creatinine, glucose, hemoglobin, and uric acid.

Mean blood serum pesticide residues of males and females in the general population of the United States have been published by Durham, who reported levels significantly higher in males than in females (*6*). Except for dieldrin, residues reported in the present study are also significantly higher in males and similarly follow the levels for DDT and its congeners (Table 1). Davies et al. (*4*) and Watson et al. (*13*) also demonstrated higher levels of DDT in the blood of males.

Of the many variables analyzed, county of residence is the single most important factor in explaining pesticide residue level. Table 1 was prepared by grouping counties which have geographic and agrarian similarities.

Residents of Benzie, Grand Traverse, and Leelanau counties show markedly higher mean residues than do Michigan residents in general. These are intensive orchard-growing counties in the northwestern part of the lower peninsula. During the growing season trees are often sprayed weekly or more frequently. Although authors know of no reliable variable which can be used to predict exposure, it appears that the sample population in the three orchard counties had had a greater than average exposure.

Genesee, Livingston, and Ogemaw counties have a greater proportion of male and rural residents in their samples, which may explain the greater residues found. Agriculture in these counties is a general type, not requiring heavy use of pesticides.

The Newaygo County sample also had a greater proportion of male and rural residents. Additionally, this county has some large muck soil areas which are intensively cultivated as truck farms. Large quantities of pesticides are applied regularly during the growing season by conventional ground spray rigs and by aircraft. These facts would lead one to expect residues in excess of the ones found.

Dickinson County in Michigan's upper peninsula is oriented toward dairy cattle, and pesticides are used con-

TABLE 1. *Pesticide residues in blood by county of residence, Michigan*—1968-70

County	Sample Size	Average Blood Residue Levels, ppb			
		p,p'-DDE	*p,p'*-DDT	∑ DDT	Dieldrin
Alger	39	6.75	2.36	9.93	0.13
Chippewa	1	—	—	—	—
Delta	4	—	—	—	—
Dickinson	13	22.26	5.44	30.24	0.00
Gogebic	98	14.02	3.02	18.65	0.27
Houghton	1	—	—	—	—
Iron	30	21.29	4.45	28.16	0.15
Luce	31	9.19	3.15	14.54	0.23
Mackinac	24	7.52	3.31	12.10	0.25
Ontonagon	92	14.73	3.88	20.20	0.32
Schoolcraft	6	—	—	—	—
Benzie	63	34.83	7.66	46.70	0.34
Grand Traverse	45	27.80	11.20	43.17	0.32
Leelanau	67	34.23	8.76	46.89	0.33
Antrim	16	22.22	5.52	30.28	0.00
Arenac	6	—	—	—	—
Charlevoix	1	—	—	—	—
Clare	1	—	—	—	—
Genesee	14	30.68	7.77	41.96	0.09
Gladwin	102	11.78	5.71	19.60	0.23
Hillsdale	24	19.54	5.91	27.68	0.42
Ingham	2	—	—	—	—
Iosco	17	22.44	5.06	30.06	0.17
Isabella	9	—	—	—	—
Livingston	140	22.97	6.09	31.67	0.12
Manistee	9	—	—	—	—
Midland	21	18.73	5.57	26.43	0.38
Monroe	1	—	—	—	—
Muskegon	1	—	—	—	—
Newaygo	76	24.06	7.34	34.15	0.24
Oakland	3	—	—	—	—
Ogemaw	35	30.86	6.44	40.83	0.00
Osceola	1	—	—	—	—
Roscommon	13	20.25	5.28	27.85	0.30
Saginaw	1	—	—	—	—
Shiawassee	1	—	—	—	—
Washtenaw	3	—	—	—	—
Wayne	2	—	—	—	—
Overall Sample Average	960	20.56	5.76	28.86	0.23

Note:— = counties which had fewer than 10 residents sampled. Such counties were not included in the intercounty comparisons, but were included in the overall comparisons.

siderably less than in fruit and vegetable production. Rural residents and males comprised a smaller proportion for this county than for any other sampled. All other upper peninsula counties which were sampled showed lower residues than the average for the State. It is thus difficult to understand why the Dickinson County sample had higher residues.

Residue levels of *p,p'*-DDT, *p,p'*-DDE, and ∑DDT increase with age (Table 2). The increases were, however, somewhat inconsistent in age groups under 45. Dieldrin levels also increased with age but were less consistent than the DDT residues.

For analytical purposes, blood chemistry values were grouped as low, normal, and high as shown in Table 3.

No association was found between hemoglobin levels and blood pesticide residues (Table 4). Residues of dieldrin were found in quite small amounts and were often undetectable in individuals of the sample population, but there appeared to be a positive association between blood glucose levels and dieldrin residue levels. Additionally, the mean dieldrin residues for normal and high quantities of glucose were significantly different from mean residues for the low glucose level.

Considerable association was found between increasing cholesterol levels and increasing residues of *p,p'*-DDE, ∑DDT, and dieldrin. In addition, the uric acid levels increased as the mean for these residues increased, even though the significance limit was not achieved for *p,p'*-DDT residues with cholesterol. The Food and Drug Administration, U.S. Department of Health, Education, and Welfare, began an expanded surveillance and compliance food monitoring program in 1963 which has indicated that the combination of meat, fish, poultry, and dairy products accounts for over half the human intake of chlorinated organic pesticides (*5*). The associations which the authors found between cholesterol and residues, and between uric acid levels and residues, tempt one to postulate that increased animal protein intake might cause increased organochlorine pesticide residues in humans (Table 3).

Creatinine levels and residues of *p,p'*-DDT, *p,p'*-DDE, and ∑DDT showed a positive association which may well be explained using the same hypothesis as above (Table 4).

Persons whose occupations were listed as possibly related to pesticide use had significantly higher levels of *p,p'*-

TABLE 2. *Pesticide residues in blood by sex and age of Michigan residents, 1968–70*

		Average Blood Residue Levels, ppb			
	N	*p,p'*-DDT	*p,p'*-DDE	∑ DDT [1]	Dieldrin
Male	516	6.52	23.74	33.36 (507)	0.319
Female	494	4.98	17.40	24.65 (478)	0.129
≤29 Male	28	6.62	23.92	33.48 (27)	0.210
≤29 Female	40	4.47	14.54	21.30 (38)	0.110
30–34 Male	45	4.92	19.34	26.47	0.290
30–34 Female	47	4.20	14.78	20.66	—
35–39 Male	48	8.33	24.24	36.05	0.200
35–39 Female	52	4.44	15.42	21.30 (50)	0.020
40–44 Male	67	5.35	22.28	31.37 (65)	0.230
40–44 Female	58	4.19	16.62	23.06 (57)	0.080
45–49 Male	52	5.95	23.00	31.68	0.450
45–49 Female	63	4.66	17.12	23.95 (62)	0.000
50–54 Male	83	6.29	22.62	31.76 (82)	0.310
50–54 Female	64	5.16	16.88	24.71 (58)	0.160
55–59 Male	58	5.92	25.33	34.13	0.290
55–59 Female	62	4.97	18.97	26.17 (60)	0.180
60–64 Male	52	6.85	25.73	36.13 (51)	0.440
60–64 Female	54	5.75	20.15	28.89 (52)	0.040
65+ Male	83	8.03	26.16	37.68 (79)	0.380
65+ Female	54	6.84	20.96	30.23	0.460
Urban Male	278	6.45	22.06	31.42 (275)	0.330
Rural Male	238	6.59	25.69	35.66 (232)	0.300
Urban Female	246	4.79	16.17	23.15 (205)	0.150
Rural Female	248	5.17	18.63	26.11 (243)	0.110
Urban Total	524	5.67	19.29	27.61 (510)	0.240
Rural Total	486	5.87	22.09	30.77 (475)	0.210

[1] Numbers in parentheses indicate sample size different from that given in "N" column.

TABLE 3. *Blood chemistry values of Michigan residents sampled for pesticide residues, 1968–70*

	Hemoglobin		Glucose	Cholesterol	Uric Acid	Creatinine
	Males	Females				
	G.%			Mg.%		
Low	14	12	80	140	3	
Normal	14–18	12–16	80–120	140–270	3–6.3	0.5–1.3
High	> 18	> 16	> 120	> 270	> 6.3	> 1.3

TABLE 4. *Pesticide residues in Michigan residents by sex, location, and selected biochemistries, 1968–70*

		Average Blood Residue Levels, ppb			
	N	*p,p'*-DDT	*p,p'*-DDE	∑DDT	Dieldrin
Unknown Occupation	59	5.55	19.37	27.37	0.166
Possible Pesticide	67	6.96	26.93	37.09	0.336
Not Pesticide Related	884	5.69	20.25	28.43	0.222
p-Value		*0.21*	*0.002*	*NC*	*0.250*
Low Hemoglobin	37	7.10	30.51	41.09	0.392
Normal Hemoglobin	590	6.76	25.30	35.05	0.233
High Hemoglobin	16	7.78	30.66	41.93	0.348
p-Value		*0.79*	*0.07*	*0.13*	*0.300*
Low Glucose	143	6.39	25.76	35.08	0.099
Normal Glucose	415	7.32	26.95	37.45	0.244
High Glucose	41	6.45	24.56	34.18	0.358
p-Value		*0.30*	*0.54*	*0.41*	*0.018*
Low Cholesterol	9	5.19	18.91	26.26	0.133
Normal Cholesterol	632	6.08	22.84	31.60	0.207
High Cholesterol	112	6.99	29.01	39.45	0.412
p-Value		*0.32*	*≤0.0005*	*0.001*	*0.005*
Low Uric Acid	31	4.12	16.88	22.93	0.035
Normal Uric Acid	559	5.68	22.77	31.05	0.171
High Uric Acid	169	8.31	28.35	40.26	0.481
p-Value		*<0.0005*	*<0.0005*	*<0.0005*	*<0.0005*
Normal Creatinine	724	6.05	23.28	32.06	0.229
High Creatinine	42	9.40	32.52	45.64	0.348
p-Value		*0.001*	*<0.0005*	*<0.0005*	*0.230*

Note: Results from the Student-Newman-Keuls tests (alpha = 0.05) are indicated by the presence of a vertical line which is interpreted as follows: any two means not connected by the same line are significantly different, and any two means connected by the same line are not significantly different.

The *p*-value is given for the one-way analysis of variance which tests for the equality of means. Where the *p*-value is ≤0.10 then Student-Newman-Keuls tests were computed to determine which means were important.

NC = statistical test not computed.

DDE in their blood than had those whose occupations were not pesticide related. Dieldrin levels were also higher in this group, but statistical significance was not shown (Table 4).

When blood residues of the major DDT constituents and dieldrin are compared with residence, age, and sex, several general patterns emerge. Persons in rural areas tend to have greater residues of DDE; residues of $\sum$DDT and dieldrin tend to increase with age; and males have greater residues than have females. The cause of these relationships is undetermined (Table 2).

In general, the study showed that the county of residence was the most significant factor for determining pesticide residue levels. Occupation, sex, and location of residence were also determined to be associated with blood residue levels. Residues of $\sum$DDT and dieldrin were greater in elder persons. No relationships were detected between blood hemoglobin and blood residue values. As the blood levels of glucose, cholesterol, uric acid, and creatinine increased, so generally did the levels of pesticide residues. However, when all variables were used, no equation could be developed which would reliably predict a blood residue level given those demographic characteristics.

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PESTICIDES IN FOOD AND FEED

Pesticide and Other Chemical Residues in Total Diet Samples (XI)

R. D. Johnson and D. D. Manske [1]

ABSTRACT

In the Total Diet study, the Food and Drug Administration has, since 1964, reported residues of pesticides and other chemicals ingested in the average diet of the Nation's largest eater, the young adult male. During the eleventh year of the study, pesticide residues remained at the relatively low levels reported previously. Twenty market baskets were collected in 20 cities which ranged in population from less than 50,000 to 1,000,000 or more. Averages and ranges of residues found are reported for August 1974 through July 1975 by food class. The individual items used in making up the dairy and meat composites in four market baskets were analyzed for pesticides and the results are included. Data for lead, cadmium, selenium, mercury, arsenic, and zinc are also included. Results of recovery studies within various classes of residues are also presented.

Introduction

The Food and Drug Administration Total Diet Program, sometimes called the Market Basket study, began with a program intended for surveillance of fission products for atomspheric tests of thermonuclear weapons in May 1961 (9). The program was quickly extended to pesticides and certain nutrients. Although changes have been made in sampling frequency, areas sampled, analytical methods, and types of residues sought, the program has continued in essentially the same form to the present. A market basket of food representing the basic 2-week diet of a 16- to 19-year-old male, statistically the Nation's largest eater, is collected in each of several geographic areas. The various foods are prepared, e.g., by cooking, in the manner in which they would normally be served and eaten. The foods in each of 12 broad classes are then composited into a slurry and analyzed for organochlorine and organophosphorus pesticides, carbaryl, herbicides, certain metals, and polychlorinated biphenyls (PCB's). Methodology includes atomic absorption spectroscopy, fluorometry, gas chromatography, thin-layer chromatography, mass spectroscopy, and established extraction and cleanup techniques. Conditions, techniques, and limits of quantitation have been described in previous reports in this series (*1–5, 12–15, 20*). Amounts and types of residues found from June 1964 through July 1974 have also been described in earlier reports (*6–8, 10, 11, 15–19*). The present report presents the results obtained from August 1974 through July 1975. Samples were collected in 20 different grocery markets in 20 different cities.

In addition, 10 market baskets of an Infant and Toddler series were analyzed for the first time and the data will be presented in a separate paper.

Results

During this reporting period 959 residues of 42 different compounds were found in 240 composites examined. In the previous reporting period, 1,613 residues of 42 different compounds were found in the 360 composites examined. The 42 different residues found are listed in decreasing order of frequency in Table 1. In Table 2, the frequency of occurrence of these residues is broken down according to food class. Table 3 gives the levels of the chemical residues by the food class in which they appeared. The average stated in Table 3 is based on 20 composites examined; no trace residues have been included in calculating the average. For this reason, an average value reported as "T" can be well below the detection limits of the methods for that compound.

The most common residues and their maximum levels are discussed below for each of the 12 food classes. No findings have been corrected for recoveries obtained in recovery experiments.

DAIRY PRODUCTS

Organochlorine compounds were the residues found most frequently in dairy products. The most common organochlorines were dieldrin, 0.005 ppm; BHC, 0.0012 ppm; DDE, 0.017 ppm; and heptachlor epoxide, 0.003 ppm. Other organochlorine residues present were HCB, methoxychlor, octachlor epoxide, lindane, and PCP. Zinc,

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TABLE 1. *Chemical residues found in food composites, August 1974–July 1975*

Chemical Found	No. Composites with Residues	No. Positive Composites with Residues Reported as Trace[1]	Range, ppm
Zinc	239	0	0.3–33.5
Cadmium	141	113	0.05–0.14
Lead	78	31	0.1–1.6
Selenium	59	19	0.10–0.42
Dieldrin Not less than 85% of 1,2,3,4,10,10–hexachloro–6,7–epoxy–1,4,4a,5,6,7,8,8a–octahydro–1,4–*endo*–*exo*–5,8–dimethanonaphthalene	56	8	0.001–0.015
BHC 1,2,3,4,5,6–hexachlorocyclohexane, mixed isomers except gamma	47	11	0.0004–0.0190
DDE 1,1–dichloro–2,2–bis (*p*–chlorophenyl) ethylene (isomers other than $_{p,p'}$ also included in reportings)	46	10	0.001–0.033
Malathion diethylmercaptosuccinate, *S*–ester with *O,O*–dimethyl phosphorodithioate	34	5	0.003–0.144
Diazinon *O,O*–diethyl *O*–(2–isopropyl–6–methyl–4–pyrimidyl) phosphorothioate	28	12	0.001–0.019
Heptachlor Epoxide 1,4,5,6,7,8,8–heptachloro–2,3–epoxy–3a,4,7,7a–tetrahydro–4,7–methanoindan	25	10	0.0006–0.003
Mercury	22	17	0.02
DDT 1,1,1–trichloro–2,2–bis (*p*–chlorophenyl) ethane (isomers other than $_{p,p'}$ also included in reportings)	20	9	0.003–0.016
HCB hexachlorobenzene	20	10	0.0002–0.017
Lindane 1,2,3,4,5,6–hexachlorocyclohexane, 99% or more gamma isomer	19	10	0.0007–0.0140
Arsenic (As_2O_3)	17	13	0.10–0.16
PCP pentachlorophenol	13	0	0.010–0.040
CIPC isopropyl *n*–(3–chlorophenyl) carbamate	12	0	0.003–0.653
Octachlor Epoxide 1–*exo*–2–*endo*–4,5,6,7,8,8–octachloro–2,3–epoxy–2,3,3a,4,7,7a–hexahydro–4,7–methanoindene	9	8	0.004
TDE 1,1–dichloro–2,2–bis (*p*–chlorophenyl) ethane (isomers other than $_{p,p'}$ also included in reportings)	9	5	0.002–0.004
PCB (polychlorinated biphenyls); calculated as Aroclor® with varied chlorine content	8	8	T
Endosulfan 6,7,8,10,10–hexachloro–1,5,5a,6,9,9a–hexahydro–6,9–methano–2,4,3–benzodioxathiepin 3–oxide (reportings include isomers I, II, and the sulfate)	7	2	0.004–0.022
Parathion *O,O*–diethyl *O*–*p*–nitrophenyl phosphorothioate	6	1	0.002–0.013
PCNB pentachloronitrobenzene	6	3	0.001–0.003
Botran® 2,6–dichloro–4–nitroaniline	5	0	0.001–0.016
PCA pentachloroaniline	5	0	0.002–0.035
Dicofol (Kelthane®) 4,4'–dichloro–a–)trichloromethyl) benzhydrol	3	0	0.006–0.033
Methyl Parathion *O,O*–dimethyl *O*–*p*–nitrophenyl phosphorothioate	3	0	0.0001–0.0010
Pentachlorobenzene	3	0	0.0005-0.0060
Carbaryl 1–naphthyl *n*–methyl carbamate	2	1	0.07

(Continued next page)

TABLE 1 (cont'd.). *Chemical residues found in food composites, August 1974–July 1975*

Chemical Found	No. Composites with Residues	No. Positive Composites with Residues Reported as Trace[1]	Range, ppm
Ethion *O,O,O,O'*–tetraethyl *S,S'*–methylene bisphosphorodithioate	2	1	0.061
Methoxychlor 1,1,1–trichloro–2,2–bis (*p*–methoxyphenyl) ethane	2	1	0.007
Orthophenylphenol 2–hydroxydiphenyl	2	1	0.20
TCNB 1,2,4,5–tetrachloro–3–nitrobenzene	2	0	0.001–0.075
Aldrin Not less than 95% of 1,2,3,4,10,10–hexachloro–1,4,4a,5,8,8a–hexahydro–1,4–*endo*–*exo*–5,8–dimethanonaphthalene	1	0	0.007
DCPA (Dacthal®) 2,3,5,6–tetrachloroterephthalic acid dimethyl ester	1	0	0.003
Endrin 1,2,3,4,10,10–hexachloro–6,7–epoxy–1,4,4a,5,6,7,8,8a–octahydro–1,4–*endo*–*endo*–5,8–dimethanonaphthalene	1	1	T
Leptophos *O*–(2,5–dichloro–4–bromophenyl)–*O*–methyl phenyl–phosphorothioate	1	0	0.040
Nonachlor 1,2,3,4,5,6,7,8,8–nonachloro–3a–4,7,7a–tetrahydro–4,7–*endo*–methanoindane	1	0	0.003
Perthane® 1,1–dichloro, 2,2–bis (*p*–ethylphenyl) ethane	1	0	0.142
Phosalone *O,O*–diethyl *S*–(6–chloro–2–oxobenzoxazolin–3–yl) methyl phosphorodithioate	1	0	0.025
Ronnel *O,O*–dimethyl (*O*–2,4,5–trichlorophenyl) phosphorothioate	1	0	0.004
Toxaphene chlorinated camphene containing 67 to 69% chlorine	1	0	0.118

[1] Chemicals capable of being detected by the specific analytical methodology may be confirmed qualitatively but are not quantifiable when they are present at concentrations below the limit of quantitation. Limit of quantitation varies with residue and food class.

TABLE 2. *Occurrence frequency of chemical residues by food class, August 1974–July 1975*

Chemical	Food Class											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Number of Occurrences											
Zinc	20	20	20	20	20	20	20	20	19	20	20	20
Cadmium	4	11	19	20	20	3	16	17	5	17	8	1
Lead		4	3	2	11	19	14	14	8		1	2
Selenium	5	20	20	1		6	1	2		2	2	
Dieldrin	17	19		7				12		1		
BHC	19	16	2				1	5		1	3	
DDE	11	20		7	6		1				1	
Malathion			19		1					12	2	
Diazinon		4	8		9		1	3	1	2		
Heptachlor Epoxide	11	13						1				
Mercury		20			1					1		
DDT		13		6							1	
HCB	8	7								4	1	
Lindane	1	6	3					5			4	
Arsenic		13	1	2								1
PCP	1		2		1		2	1	1		5	
CIPC				11					1			
Octachlor Epoxide	2	7										
TDE		9										
PCB		8										
Endosulfan					5			2				
Parathion					4		1	1				
PCNB									1	4	1	
Botran					4				1			
Pentachloroaniline										4	1	
Dicofol									3			
Methyl Parathion					3							
Pentachlorobenzene										2	1	
Carbaryl								1	1			
Ethion									2			

(Continued next page)

TABLE 2 (cont'd.). *Occurrence frequency of chemical residues by food class, August 1974–July 1975*

Chemical	Food Class											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Number of Occurrences											
Methoxychlor	2											
Orthophenylphenol								1	1			
TCNB			1	1								
Aldrin			1									
DCPA								1				
Endrin		1										
Leptophos								1				
Nonachlor		1										
Perthane					1							
Phosalone									1			
Ronnel			1									
Toxaphene					1							

[1]See Table 3 for description of food class.

TABLE 3. *Levels of chemical residues found by food class, August 1974–July 1975*

Residues, ppm

I. Dairy Products

ZINC		SELENIUM	
Average	4.9	Average	T
Positive Composites		Positive Composites	
Total Number	20	Total Number	5
Number Reported as Trace	0	Number Reported as Trace	5
Range	1.5–8.9	Range	T
BHC		CADMIUM	
Average	0.0005	Average	T
Positive Composites		Positive Composites	
Total Number	19	Total Number	4
Number Reported as Trace	5	Number Reported as Trace	4
Range	0.0004–0.0012	Range	T
DIELDRIN		METHOXYCHLOR	
Average	0.002	Average	T
Positive Composites		Positive Composites	
Total Number	17	Total Number	2
Number Reported as Trace	1	Number Reported as Trace	1
Range	0.001–0.005	Range	T–0.007
DDE		OCTACHLOR EPOXIDE	
Average	0.002	Average	T
Positive Composites		Positive Composites	
Total Number	11	Total Number	2
Number Reported as Trace	3	Number Reported as Trace	2
Range	0.001–0.017	Range	T
HEPTACHLOR EPOXIDE		LINDANE	
Average	0.0004	Average	T
Positive Composites		Positive Composites	
Total Number	11	Total Number	1
Number Reported as Trace	5	Number Reported as Trace	1
Range	0.0006–0.003	Range	T
HCB		PCP	
Average	0.0001	Average	0.0005
Positive Composites		Positive Composites	
Total Number	8	Total Number	1
Number Reported as Trace	5	Number Reported as Trace	0
Range	0.0002–0.0010	Range	0.0100

II. Meat, Fish, and Poultry

DDE		DDT	
Average	0.009	Average	0.004
Positive Composites		Positive Composites	
Total Number	20	Total Number	13
Number Reported as Trace	2	Number Reported as Trace	4
Range	0.003–0.033	Range	0.003–0.016
MERCURY		HEPTACHLOR EPOXIDE	
Average	T	Average	0.001
Positive Composites		Positive Composites	
Total Number	20	Total Number	13
Number Reported as Trace	15	Number Reported as Trace	4
Range	T–0.02	Range	0.001–0.003

(Continued next page)

TABLE 3 (cont'd.). *Level of chemical residues found by food class, August 1974-July 1975*

	Residues, ppm
SELENIUM	
Average	0.25
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	0.17–0.37
ZINC	
Average	27.6
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	23.4–33.5
DIELDRIN	
Average	0.004
Positive Composites	
Total Number	19
Number Reported as Trace	1
Range	0.002–0.015
BHC	
Average	0.0005
Positive Composites	
Total Number	16
Number Reported as Trace	4
Range	0.0005–0.0010
ARSENIC	
Average	0.03
Positive Composites	
Total Number	13
Number Reported as Trace	9
Range	0.10–0.16
LINDANE	
Average	0.0002
Positive Composites	
Total Number	6
Number Reported as Trace	4
Range	0.0018–0.0020
DIAZINON	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	3
Range	T–0.0020
LEAD	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	4
Range	T
CADMIUM	
Average	T
Positive Composites	
Total Number	11
Number Reported as Trace	11
Range	T
TDE	
Average	0.001
Positive Composites	
Total Number	9
Number Reported as Trace	5
Range	0.002–0.004
PCB	
Average	T
Positive Composites	
Total Number	8
Number Reported as Trace	8
Range	T
HCB	
Average	T
Positive Composites	
Total Number	7
Number Reported as Trace	3
Range	0.001–0.002
OCTACHLOR EPOXIDE	
Average	T
Positive Composites	
Total Number	7
Number Reported as Trace	6
Range	T–0.004
ENDRIN	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
NONACHLOR	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.003

III. Grain and Cereal Products

SELENIUM	
Average	0.24
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	0.10–0.42
ZINC	
Average	8.5
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	4.1–11.7
CADMIUM	
Average	T
Positive Composites	
Total Number	19
Number Reported as Trace	17
Range	0.05–0.08
MALATHION	
Average	0.017
Positive Composites	
Total Number	19
Number Reported as Trace	0
Range	0.005–0.043
DIAZINON	
Average	0.001
Positive Composites	
Total Number	8
Number Reported as Trace	4
Range	0.002–0.008
LEAD	
Average	0.01
Positive Composites	
Total Number	3
Number Reported as Trace	2
Range	T–0.18

(Continued next page)

TABLE 3 (cont'd.). *Level of chemical residues found by food class, August 1974-July 1975*

Residues, ppm	
LINDANE	
Average	0.0001
Positive Composites	
Total Number	3
Number Reported as Trace	1
Range	0.0007–0.0020
BHC	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	T–0.0010
PCP	
Average	0.001
Positive Composites	
Total Number	2
Number Reported as Trace	0
Range	0.010–0.013
ALDRIN	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.0070
ARSENIC	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
RONNEL	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.0040
TCNB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.001

IV. Potatoes

CADMIUM	
Average	0.04
Positive Composites	
Total Number	20
Number Reported as Trace	7
Range	0.05–0.12
ZINC	
Average	4.9
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	2.3–7.7
DIELDRIN	
Average	0.001
Positive Composites	
Total Number	7
Number Reported as Trace	2
Range	0.001–0.008
DDT	
Average	T
Positive Composites	
Total Number	6
Number Reported as Trace	4
Range	T–0.004
ARSENIC	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
CIPC	
Average	0.112
Positive Composites	
Total Number	11
Number Reported as Trace	0
Range	0.004–0.653
DDE	
Average	0.002
Positive Composites	
Total Number	7
Number Reported as Trace	2
Range	0.002–0.025
LEAD	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
SELENIUM	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
TCNB	
Average	0.004
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.075

V. Leafy Vegetables

CADMIUM	
Average	0.05
Positive Composites	
Total Number	20
Number Reported as Trace	7
Range	0.05–0.14
ZINC	
Average	3.1
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	1.4–10.9
DIAZINON	
Average	0.003
Positive Composites	
Total Number	9
Number Reported as Trace	0
Range	0.001–0.019
DDE	
Average	T
Positive Composites	
Total Number	6
Number Reported as Trace	2
Range	0.003–0.005

(Continued next page)

TABLE 3 (cont'd.). *Level of chemical residues found by food class, August 1974-July 1975*

	Residues, ppm
LEAD	
Average	0.06
Positive Composites	
Total Number	11
Number Reported as Trace	4
Range	0.11–0.32
BOTRAN	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	0
Range	0.001–0.006
PARATHION	
Average	0.001
Positive Composites	
Total Number	4
Number Reported as Trace	0
Range	0.002–0.013
METHYL PARATHION	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	0
Range	0.001–0.010
MALATHION	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.009
ENDOSULFAN	
Average	0.002
Positive Composites	
Total Number	5
Number Reported as Trace	1
Range	0.004–0.022
MERCURY	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
PCP	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.013
PERTHANE	
Average	0.007
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.142
TOXAPHENE	
Average	0.006
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.118
VI. Legume Vegetables	
ZINC	
Average	7.7
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	2.7–12.0
LEAD	
Average	0.26
Positive Composites	
Total Number	19
Number Reported as Trace	2
Range	0.10–1.60
SELENIUM	
Average	T
Positive Composites	
Total Number	6
Number Reported as Trace	6
Range	T
CADMIUM	
Average	T
Positive Composites	
Total Number	3
Number Reported as Trace	3
Range	T
VII. Root Vegetables	
ZINC	
Average	4.1
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	1.4–28.6
CADMIUM	
Average	T
Positive Composites	
Total Number	16
Number Reported as Trace	16
Range	T
LEAD	
Average	0.16
Positive Composites	
Total Number	14
Number Reported as Trace	5
Range	0.17–1.10
PCP	
Average	0.001
Positive Composites	
Total Number	2
Number Reported as Trace	0
Range	0.010
DDE	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
DIAZINON	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
PARATHION	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.002
SELENIUM	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T

(Continued next page)

TABLE 3 (cont'd.). *Level of chemical residues found by food class, August 1974-July 1975*

	Residues, ppm
BHC	
Average	0.0005
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.010

VIII. Garden Fruits

ZINC		CADMIUM	
Average	3.1	Average	T
Positive Composites		Positive Composites	
Total Number	20	Total Number	17
Number Reported as Trace	0	Number Reported as Trace	17
Range	0.9–12.2	Range	T
LEAD		CARBARYL	
Average	0.08	Average	T
Positive Composites		Positive Composites	
Total Number	14	Total Number	1
Number Reported as Trace	5	Number Reported as Trace	1
Range	0.10–0.50	Range	T
DIELDRIN		DCPA	
Average	0.002	Average	T
Positive Composites		Positive Composites	
Total Number	12	Total Number	1
Number Reported as Trace	3	Number Reported as Trace	0
Range	0.002–0.008	Range	0.003
BHC		HEPTACHLOR EPOXIDE	
Average	0.0016	Average	T
Positive Composites		Positive Composites	
Total Number	5	Total Number	1
Number Reported as Trace	0	Number Reported as Trace	1
Range	0.0016–0.0190	Range	T
LINDANE		LEPTOPHOS	
Average	0.0004	Average	0.002
Positive Composites		Positive Composites	
Total Number	5	Total Number	1
Number Reported as Trace	3	Number Reported as Trace	0
Range	0.0030–0.0060	Range	0.040
DIAZINON		ORTHOPHENYLPHENOL	
Average	T	Average	T
Positive Composites		Positive Composites	
Total Number	3	Total Number	1
Number Reported as Trace	2	Number Reported as Trace	1
Range	T–0.001	Range	T
ENDOSULFAN		PARATHION	
Average	T	Average	T
Positive Composites		Positive Composites	
Total Number	2	Total Number	1
Number Reported as Trace	1	Number Reported as Trace	1
Range	T–0.006	Range	T
SELENIUM		PCP	
Average	T	Average	T
Positive Composites		Positive Composites	
Total Number	2	Total Number	1
Number Reported as Trace	2	Number Reported as Trace	0
Range	T	Range	0.010

IX. Fruits

ZINC		CIPC	
Average	1.2	Average	T
Positive Composites		Positive Composites	
Total Number	19	Total Number	1
Number Reported as Trace	0	Number Reported as Trace	0
Range	0.3–4.4	Range	0.003
LEAD		DIAZINON	
Average	0.02	Average	T
Positive Composites		Positive Composites	
Total Number	8	Total Number	1
Number Reported as Trace	5	Number Reported as Trace	1
Range	0.10–0.11	Range	T

(Continued next page)

TABLE 3 (cont'd.). *Level of chemical residues found by food class, August 1974-July 1975*

	Residues, ppm
CADMIUM	
Average	T
Positive Composites	
Total Number	5
Number Reported as Trace	5
Range	T
DICOFOL	
Average	0.002
Positive Composites	
Total Number	3
Number Reported as Trace	0
Range	0.006–0.033
ETHION	
Average	0.003
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	T–0.061
BOTRAN	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.016
CARBARYL	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.07
ORTHOPHENYLPHENOL	
Average	0.01
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.20
PCNB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.001
PCP	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.011
PHOSALONE	
Average	0.001
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.025

X. Oils, Fats, and Shortening

ZINC	
Average	5.6
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	1.0–18.4
CADMIUM	
Average	T
Positive Composites	
Total Number	17
Number Reported as Trace	17
Range	T
MALATHION	
Average	0.023
Positive Composites	
Total Number	12
Number Reported as Trace	4
Range	0.012–0.144
HCB	
Average	0.001
Positive Composites	
Total Number	4
Number Reported as Trace	2
Range	0.001–0.017
PCA	
Average	0.002
Positive Composites	
Total Number	4
Number Reported as Trace	0
Range	0.003–0.035
PCNB	
Average	T
Positive Composites	
Total Number	4
Number Reported as Trace	2
Range	0.001–0.003
DIAZINON	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	T-0.004
PENTACHLOROBENZENE	
Average	0.0003
Positive Composites	
Total Number	2
Number Reported as Trace	0
Range	0.0010–0.006
SELENIUM	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
BHC	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
DIELDRIN	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
MERCURY	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T

(Continued next page)

TABLE 3 (cont'd.). *Level of chemical residues found by food class, August 1974-July 1975*

	Residues, ppm
XI. Sugars and Adjuncts	
ZINC	
Average	3.4
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	0.6–13.0
CADMIUM	
Average	T
Positive Composites	
Total Number	8
Number Reported as Trace	8
Range	T
PCP	
Average	0.006
Positive Composites	
Total Number	5
Number Reported as Trace	0
Range	0.010–0.040
LINDANE	
Average	0.0008
Positive Composites	
Total Number	4
Number Reported as Trace	1
Range	0.0007–0.0140
BHC	
Average	0.0001
Positive Composites	
Total Number	3
Number Reported as Trace	0
Range	0.0009–0.0010
MALATHION	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	1
Range	T–0.003
SELENIUM	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
DDE	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.002
DDT	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
HCB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.0008
LEAD	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.12
PENTACHLOROANILINE	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.002
PCNB	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
PENTACHLOROBENZENE	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	0
Range	0.0005
XII. Beverages	
ZINC	
Average	0.8
Positive Composites	
Total Number	20
Number Reported as Trace	0
Range	0.3–4.1
LEAD	
Average	T
Positive Composites	
Total Number	2
Number Reported as Trace	2
Range	T
ARSENIC	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T
CADMIUM	
Average	T
Positive Composites	
Total Number	1
Number Reported as Trace	1
Range	T

NOTE: Average residues are based on 20 composites examined. No trace residues were included; hence average value reported as "T" can be well below detection limits of the method for that compound.

ranging from 1.5 to 8.9 ppm, was found in all 20 composites. Selenium and cadmium were occasionally found in this food class. No organophosphorus residues were detected.

MEAT, FISH, AND POULTRY

Twelve organochlorine compounds occurred in varying combinations in all 20 composites. The most common were DDE, 0.033 ppm; dieldrin, 0.015 ppm; BHC, 0.0010 ppm;

DDT, 0.016 ppm; and heptachlor epoxide, 0.003 ppm. Other residues were TDE, PCB, HCB, octachlor epoxide, lindane, diazinon, endrin, and nonachlor. Mercury, selenium, and zinc, ranging from trace to 0.02 ppm, 0.17 to 0.37 ppm, and 23.4 to 33.5 ppm, respectively, were found in all 20 composites; arsenic, cadmium, and lead were also found.

GRAIN AND CEREAL PRODUCTS

Selenium and zinc, ranging from 0.10 to 0.42 ppm and from 4.1 to 11.7 ppm, respectively, were found in all 20 composites. Malathion, ranging from 0.005 to 0.043 ppm, was found in 19 composites. Other residues included cadmium, diazinon, lead, lindane, BHC, PCP, aldrin, arsenic, ronnel, and TCNB.

POTATOES

Cadmium and zinc, ranging from 0.05 to 0.12 ppm and from 2.3 to 7.7 ppm, respectively, were found in all 20 composites. Of the five organochlorine residues that appeared in this composite, the most common were CIPC, 0.653 ppm; DDE, 0.025 ppm; and dieldrin, 0.008 ppm. Other residues were DDT, arsenic, lead, selenium, and TCNB.

LEAFY VEGETABLES

Organophosphates were the most frequently detected pesticide residue in leafy vegetables. The most common were diazinon, 0.019 ppm; parathion, 0.013 ppm; and methyl parathion, 0.010 ppm. Cadmium and zinc, ranging from 0.05 to 0.14 ppm and from 1.4 to 10.9 ppm, respectively, were found in all 20 composites. Lead, ranging from 0.11 to 0.32 ppm, was found in 11 composites. Less frequently occurring residues were DDT, endosulfan, botran, malathion, mercury, PCP, perthane, and toxaphene.

LEGUME VEGETABLES

Zinc, ranging from 2.7 to 12.0 ppm, was found in all 20 composites. Nineteen composites contained lead ranging from 0.10 to 1.60 ppm. Selenium and cadmium were also found occasionally. No organochlorine or organophosphates were detected in this composite.

ROOT VEGETABLES

Zinc, ranging from 1.4 to 28.6 ppm, was found in all 20 composites. Cadmium was found 16 times at the trace level in this food class. Lead, ranging from 0.17 to 1.10 ppm, was found in 14 composites. Other residues found were PCP, BHC, DDE, diazinon, parathion, and selenium.

GARDEN FRUITS

The most common pesticide residues in garden fruits were dieldrin, 0.008 ppm; BHC, 0.0190 ppm; lindane, 0.0060 ppm; and diazinon, 0.001 ppm. Twenty composites contained zinc ranging from 0.9 to 12.2 ppm. Other residues were cadmium, lead, endosulfan, selenium, carbaryl, DCPA, heptachlor epoxide, leptophos, orthophenylphenol, parathion, and PCP.

FRUITS

Dicofol, 0.033 ppm, and ethion, 0.061 ppm, were the most frequently encountered pesticide residues. Other residues were zinc, lead, cadmium, botran, carbaryl, CIPC, diazinon, orthophenylphenol, PCNB, PCP, and phosalone.

OILS, FATS, AND SHORTENING

The most common nonmetallic residues were malathion, 0.144 ppm; HCB, 0.17 ppm; PCA, 0.035 ppm; and PCNB, 0.003 ppm. Twenty composites contained zinc ranging from 1.0 to 18.4 ppm. Other residues were cadmium, diazinon, pentachlorobenzene, selenium, BHC, dieldrin, and mercury.

SUGARS AND ADJUNCTS

The most frequently found organochlorine residues were PCP, 0.040 ppm; lindane, 0.0140 ppm; and BHC, 0.0010 ppm. Twenty composites contained zinc ranging from 0.6 to 13.0 ppm. Other residues included cadmium, malathion, selenium, DDE, DDT, HCB, lead, pentachloraniline, PCNB, and pentachlorobenzene.

BEVERAGES

No organochlorine or organophosphates were found in any of the 20 beverage composites examined. Zinc, ranging from 0.3 to 4.1 ppm, was found in all 20 composites. Lead, arsenic, and cadmium were also present.

Discussion

Of the 240 composites examined, organochlorine residues were found in 118, or 49 percent. Corresponding findings from previous years were 48 percent, 1973–74; 52 percent, 1972–73; and 54 percent, 1971–72. Organophosphorus residues in the current reporting period were found in 61 composites, or 25 percent. Corresponding findings in previous years were 28, 31, and 28 percent, respectively.

Carbaryl occurred in two composites in this reporting period, once at 0.07 ppm and once at the trace level. This is below the eight findings of carbaryl in the previous reporting period. Orthophenylphenol, which is detected by the method used for carbaryl, was found in two composites, once at trace level and once at 0.20 ppm. Orthophenylphenol was reported five times in the previous reporting period.

No chlorophenoxy acid herbicides appeared in this reporting period. Pentachlorophenol, which is detected by the

method used for chlorophenoxy acids, was found 13 times. In the previous reporting period pentachlorophenol was reported 10 times. Five of the 13 findings were in the sugar and adjuncts composite.

Zinc appeared in 239 of the 240 composites, ranging from 0.3 to 33.5 ppm. The second most commonly occurring metal, cadmium, was found in all 12 food classes. It was detected in 141 of the 240 composites examined at levels ranging from 0.05 to 0.14 ppm.

The highest of the 78 findings of lead was 1.6 ppm, and the highest of the 59 findings of selenium was 0.42 ppm. Mercury was found in 22 composites; meat, fish, and poultry contributed 20 of those findings. The highest residue of mercury was 0.02 ppm. Arsenic was found in 17 composites; meat, fish, and poultry contributed 13 of the findings. The highest arsenic residue was 0.16 ppm As_2O_3.

The individual commodity analysis for chlorinated, organophosphate, and PCP residues on food groups I (dairy) and II (meats) begun in earlier programs was continued on four samples of this period's 20 Total Diet samples. Composites I and II were selected because past data showed that the major occurrence of significant chlorinated residues was in these two groups. Individual commodity analysis results are shown in Table 4 (dairy group) and Table 5 (meat group). Three items from the dairy group, namely, buttermilk, skim milk, and nonfat dry milk, and one item from the meat group, lamb, are not shown because they contained no residues.

Recovery studies were conducted for all classes of chemicals sought throughout the entire year. Table 6 lists the recovery data for this reporting period. Each recovery experiment consisted of a single determination for the unfortified food composite and a single determination for the fortified sample. Since these were performed simultaneously, occasionally the fortification level was below the level present in the sample. In other cases, not enough recoveries were run to permit statistical evaluation. These data are not reported.

At very low fortification levels, recoveries may range from 0 to 200 percent. As the fortification level is raised, however, recovery approaches 100 percent. Recovery data indicate that individual, low-level residues reported may vary from the so-called true value but the overall findings are useful in appraising the national residue picture.

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TABLE 4. *Pesticide residues in individual commodities of dairy composite of four market basket samples, August 1974–July 1975*

Residue Found	Commodity[1,2]							
	Whole Milk (4)	Evaporated Milk (4)	Ice Cream (4)	Cottage Cheese (4)	Processed Cheese (4)	Natural Cheese (4)	Butter (4)	Ice Milk (2)
BHC								
Times Found	2	2	4	1	4	4	4	1
ppm Range	T	0.001	T–0.002	T	0.002–0.007	0.002–0.007	T–0.010	T
p,p'-DDE								
Times Found	3	2	4	2	3	4	4	1
ppm Range	T–0.003	0.005–0.017	0.002–0.030	T–0.005	0.005–0.015	0.003–0.006	T–0.220	T
Dieldrin								
Times Found	1	3	3	1	4	4	4	
ppm Range	T	T–0.004	T–0.004	T	0.004–0.016	0.002–0.008	0.002–0.039	
Heptachlor Epoxide								
Times Found			1		4	4	4	
ppm Range			T		0.002–0.005	T–0.004	T–0.006	
HCB								
Times Found		1	1		2		3	
ppm Range		T	T		T–0.002		0.002–0.006	
Lindane								
Times Found						1	1	
ppm Range						T	0.001	
Octachlor Epoxide								
Times Found							2	
ppm Range							0.005–0.008	
Methoxychlor								
Times Found					1	1		
ppm Range					0.035	0.010		
p,p'-DDT								
Times Found					1			
ppm Range					T			

[1]Buttermilk, skim milk, and nonfat dry milk not shown because no residues were found.
[2]Numbers in parentheses show the number of times that commodity was analyzed.

TABLE 5. *Pesticide residues in individual commodities of meat composite of four market basket samples, August 1974–July 1975*

Residue Found	Commodity[1,2]														
	Roast Beef (4)	Ground Beef (4)	Pork Chops (4)	Bacon (4)	Chicken (4)	Fish Fillet (4)	Fish Canned (4)	Lunch Meat (4)	Franks (4)	Beef Liver (4)	Eggs (4)	Ham (4)	Round Steak (4)	Veal (1)	Shrimp (2)
BHC															
Times Found	2	3				1	2	3	4	1		1	2	1	
ppm Range	0.001–0.002	0.001–0.002				0.001	0.001–0.004	0.002	T–0.005	0.001		0.001	T–0.001	0.006	
DDE															
Times Found	3	2	4	4	4	2	3	3	4		2	1	2	1	1
ppm Range	T–0.007	0.007–0.021	T–0.139	T–0.007	0.002–0.016	0.008–0.028	0.003–0.023	0.006–0.058	0.006–0.027		0.002–0.003	0.019	0.007–0.020	T	T
TDE															
Times Found			2	1		1	1	1	1			1			
ppm Range			T–0.023	0.003		T	0.008	T	0.005			0.015			
p,p'–DDT															
Times Found			2	2	1	1		3	3			1			
ppm Range			T–0.200	0.019–0.022	0.010	0.084		T–0.012	T–0.032			0.078			
HCB															
Times Found		2				1	2	2					1	1	
ppm Range		T				0.001	T–0.002	T–0.003					T	0.002	
Dieldrin															
Times Found	3	3	3	3	2	2	2	4	4	3	2	1	3		
ppm Range	T–0.021	0.003–0.004	T–0.002	T–0.011	T–0.002	T–0.005	T–0.002	T–0.008	0.003–0.240	T–0.020	T	T	0.001–0.006		
Heptachlor Epoxide															
Times Found	1	2		2	1	1		4	3	2		1	3		
ppm Range	0.003	0.001		T–0.003	T	T		T–0.003	T–0.004	0.003–0.004		T	T–0.051		
Lindane															
Times Found	1	2	1	1	1			3	2						
ppm Range	0.014	T	T	T	0.001			T–0.003	0.001						
PCB															
Times Found						2	1								1
ppm Range						T	0.05								T
Chlordane															
Times Found						1		2		1			1		
ppm Range						T		T		0.002			0.010		
Endrin															
Times Found					1	1									
ppm Range					T	0.003									
Octochlor Epoxide															
Times Found						1									
ppm Range						0.015									

[1]Lamb not shown because no residues found.
[2]Numbers in parentheses show the number of times that commodity was analyzed.

TABLE 6. *Recovery data on residues found in total diet samples, August 1974—July 1975*

Residue	Type of Food Composites	Spike Level, ppm	Range of Blank Level, ppm[1]	Range of Total Found, ppm[1]	No. of Recovery Studies
Cadmium	Fatty	0.1	0–0.030 (0.007)	0.089–0.171 (0.108)	20
	Nonfatty	0.1	0–0.064 (0.018)	0.068–0.174 (0.116)	37
Lead	Fatty	0.2	0–0.064 (0.014)	0.068–0.272 (0.181)	20
	Nonfatty	0.2	0–0.164 (0.041)	0.036–0.536 (0.226)	36
Selenium	Fatty	0.2	0–0.17 (0.01)	0.09–0.42 (0.19)	36
	Nonfatty	0.2	0–0.18 (0.04)	0.11–0.36 (0.021)	14
Zinc	Fatty	5	3.50–5.00 (4.53)	8.55–10.96 (9.70)	8
	Nonfatty	5	0.31–4.38 (2.43)	5.24–10.42 (7.32)	24
Mercury	Fatty	0.06	0–0.022 (0.005)	0.044–0.078 (0.059)	20
	Nonfatty	0.06	0–0.002 (<0.001)	0.042–0.067 (0.059)	40
Arsenic	Fatty	0.3	0–0.240 (0.030)	0.165–0.405 (0.305)	20
	Nonfatty	0.3	0–0.070 (0.015)	0.175–0.465 (0.320)	39
Orthophenyl-phenol	Nonfatty	0.4	0	0.08–0.40 (0.34)	40
Carbaryl	Nonfatty	0.2	0	0.06–0.20 (0.18)	40
2,4-DB	Fatty	0.02	0	0–0.019 (0.012)	8
	Nonfatty	0.02	0	0.005–0.028 (0.016)	17
2,4-D	Fatty	0.02	0	0–0.020 (0.009)	10
	Nonfatty	0.02	0	0.004–0.029 (0.016)	17
MCP	Fatty	0.02	0	0.005–0.013 (0.009)	3
	Nonfatty	0.02	0	0.006–0.025 (0.016)	8
Leptophos	Fatty	0.05	0	0.037–0.058 (0.046)	4
	Nonfatty	0.05	0	0.22–0.056 (0.037)	8
Dieldrin	Fatty	0.01	0–0.006 (0.0026)	0.0076–0.0212 (0.0124)	6
	Nonfatty	0.01	0–0.0013 (0.0002)	0.0044–0.0128 (0.0096)	12

(Continued next page)

TABLE 6 (cont'd.). *Recovery data on residues found in total diet samples, August 1974—July 1975*

Residue	Type of Food Composites	Spike Level, ppm	Range of Blank Level, ppm[1]	Range of Total Found, Studies	No. of Recovery
CIPC	Fatty	0.05	0	0.036–0.054 (0.042)	4
	Nonfatty	0.05	0–0.029 (0.005)	0.021–0.088 (0.045)	6
Ethion	Fatty	0.005	0	0.0030–0.0053 (0.0038)	4
	Nonfatty	0.005	0	0–0.0070 (0.0039)	8
Octachlor Epoxide	Nonfatty	0.003	0	0.0026–0.0039 (0.0031)	6
Parathion	Nonfatty	0.005	0	0.0031–0.0058 (0.0042)	6
Endrin	Nonfatty	0.01	0	0.0074–0.0107 (0.0092)	6

[1] Numbers in parentheses represent average residue levels.

PESTICIDES IN FISH, WILDLIFE, AND ESTUARIES

Concentrations of Total Mercury in Several Fishes from Delaware Bay, 1975 [1]

Ellen Heath Gerhart [2]

ABSTRACT

Mercury levels in eleven species of fishes collected from lower Delaware Bay in April 1975 ranged from 0.018 to 0.321 μg/g and averaged 0.092 μg/g. Raja eglanteria, *the clearnose skate, had the highest mean mercury concentration (0.214* μg/g*). No correlation was found with feeding habits. These assays provide baseline data for future measurement of mercury accumulation by fishes in this region.*

Introduction

Since the Minamata tragedy in Japan in the 1950's-1960's (*8*), reports of mercury levels in the aquatic environment have proliferated (*4, 12*). Environmental mercury monitoring in Sweden has been particularly comprehensive, revealing high mercury concentrations in many regions. Compilation of Swedish data on the subject showed upper levels of 5.0 μg/g in fish tissue (*9*); Holden (*7*) reported even higher concentrations, 9.8 μg/g in pike muscle tissue. Mercury levels up to 5.0 μg/g were found in fishes from the Lake Erie area of the United States (*14*). Total mercury concentrations are reported here for several species of Delaware Bay fishes collected in spring 1975.

Methods

Eleven species of fishes were collected in lower Delaware Bay east of Fowler Beach, Del. The fishes were caught with an otter trawl at depths of 36–220 m on April 10, 1975. Three individuals of each species were frozen separately in polyethylene bags. At the time of analysis the fishes were thawed and their total lengths were measured. From each fish two epaxial muscle samples were removed, each weighing approximately 5 g. In the case of anchovies, whole fish were analyzed.

Each sample was digested in a 250-ml Erlenmeyer flask containing 10 ml distilled water, 10 ml 36 N H_2SO_4 (AR), 10 ml 16 N HNO_3 (AR), and 2 g potassium permanganate crystals. This mixture was allowed to digest, with occasional shaking, for 16–20 hours at 30° C. A control flask containing no tissue was prepared with each set of digestions. After digestion the sample was diluted to approximately 100 ml with distilled water and quantitatively transferred to a standard BOD bottle. The concentration of total mercury was determined by the method of Hatch and Ott (*5*) using Coleman mercury-free reagents. An MAS-50 Perkin-Elmer (Coleman) mercury analyzer was calibrated at each analysis period with known mercury standards. All glassware was thoroughly washed and soaked in 10 percent nitric acid for at least 12 hours prior to analyses.

Results and Discussion

The data indicate detectable concentrations of mercury in all fish analyzed (Table 1). In contrast, mercury had not been detected in samples of water, detritus, algae, and shrimp (*Palaemonetes vulgaris*) collected at Lewes, Del., in spring 1974 (*11*).

No fishes sampled had concentrations higher than 0.5 μg/g, which is the upper permissible level recommended by the Food and Drug Administration, U.S. Department of Health, Education, and Welfare. Total mercury concentrations exceeding 0.20 μg/g are considered elevated (*1*). Only *Raja eglanteria*, the clearnose skate, showed a mean mercury value above 0.20 μg/g. The average mercury concentration of the 35 fishes analyzed was 0.092 μg/g; the range was 0.018–0.321 μg/g.

Many fish species are too mobile to be good indicators of regional mercury contamination. Fishes such as the summer flounder, winter flounder, and clearnose skate have extensive seasonal migrations and spend only part of the year in Delaware Bay. The clearnose skate returns to Delaware Bay in early spring (*3*) and the high mercury value for this fish may indicate exposure to mercury in its more southerly wintering grounds.

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TABLE 1. *Total mercury concentrations in Delaware Bay fishes, 1975*

	Total Mercury Concentrations, μg/g		Total Length Ranges, cm
	Mean[1]	Range	
Scophthalmus aquosus (Windowpane)	0.149 ± 0.081	0.666 – 0.251	21–26
Raja Eglanteria (Clearnose Skate)	0.214 ± 0.098	0.119 – 0.321	25–27 [2]
Merluccius Bilinearis (Silver Hake)	0.046 ± 0.010	0.036 – 0.060	21–28
Anchoa mitchilli (Bay Anchovy)	0.051 ± 0.029	0.032 – 0.084	5–7
Alosa pseudoharengus (Alewife)	0.065 ± 0.023	0.041 – 0.092	20–29
Urophycis chuss (Spotted Hake)	0.062 ± 0.021	0.047 – 0.077	14
Clupea harengus (Atlantic Herring)	0.104 ± 0.045	0.073 – 0.194	30–34
Paralichthys dentatus (Summer Flounder)	0.096 ± 0.044	0.052 – 0.155	15–19
Pseudopleuronectes americanus (Winter Flounder)	0.057 ± 0.029	0.023 – 0.106	18–20
Urophycis chuss (Red Hake)	0.075 ± 0.031	0.022 – 0.105	21–22
Prionotus carolinus (N. Sea Robin)	0.089 ± 0.075	0.018 – 0.168	9–13

[1] In mean column, numbers following ± represent standard deviation.
[2] Wing width

Although mercury content has been shown to be related to feeding habit (*10*), no clear correlation was found here. Plankton feeders such as herrings, alewives, and anchovies were not significantly lower in mercury than predators such as the hakes and flounders.

Studies of other saltwater and estuarine fishes have demonstrated similar or often higher mercury levels. Swedish fishes showed a range of 0.025–0.110 μg/g in the 1930's (*13*). More recent studies of Swedish coastal zone fishes report a range of 0.050–4.160 μg/g (*6*). Fishes obtained from Genoa, Italy, showed mercury levels as high as 2.593 μg/g (*2*). Estuarine fishes from Tasmania had some species in the 1.6–2.0 μg/g range although most were assayed at 0.2–0.5 μg/g (*10*). By comparison, values from Delaware Bay fishes reported in this study are relatively low.

Acknowledgments

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Residues of Organochlorine Pesticides and Polychlorinated Biphenyls and Autopsy Data for Bald Eagles, 1973–74 [1]

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ABSTRACT

Eighty-six bald eagles found sick or dead during 1973–74 in 24 States were analyzed for organochlorine compounds. DDE was detected in all caracasses; polychlorinated biphenyls (PCB's) were found in all but two. Seventy-five carcasses contained TDE and/or dieldrin. Four eagles had possibly lethal levels of dieldrin in the brain. Bald eagles continue to retain high residue levels of organochlorine pollutants. Illegal shooting remained the most common cause of death but accounted for a smaller percentage of the mortalities than in the two previous biennial collections.

Introduction

In a continuing effort to determine the reasons for the decline of the bald eagle (*Haliaeetus leucocephalus*) in the United States and to monitor residues, dead or moribund specimens are collected in the field and sent to Patuxent Wildlife Research Center by Federal, State, and private cooperators for autopsy and analysis. Residue and autopsy data for specimens collected in 1973–74 are reported in this paper; previous years' collections already have been published (*1–4*).

Sampling and Autopsy

Procedures for shipment and storage of these specimens prior to analysis have been described (*2*). No systematic collection of bald eagles has been attempted due to the relatively low population and protected status of these birds. Eighty-six specimens were collected in 24 States in 1973–74; the breakdown by State and by year appears in Table 1. Decomposed specimens were not analyzed. Autopsy procedures followed those described previously by Belisle et al. (*1*).

Analytical Procedures

After removal of the skin, feet, wings, brain, and gastrointestinal tract, the carcass was ground and homogenized in a Hobart food cutter. A 10-g aliquot and the entire brain were mixed separately with anhydrous sodium sulfate in a blendor and extracted for 7 hours with hexane in a Soxhlet apparatus. Extracts were cleaned by florisil column chromatography and the pesticides and PCB's were fractionated by Silicar column chromatography. These procedures have been described in detail by Cromartie et al. (*2*).

The fractions were analyzed with a Hewlett-Packard 5753 gas chromatograph (GC) equipped with a NI^{63} detector, automatic sampler, computing integrator, and a 4 percent SE-30/6 percent QF-1 column at 190°C. Pesticides were quantitated by computer integration of the peak areas, and

TABLE 1. *Distribution of eagles collected by State and year of death, 1973–74*

State	No. Eagles Collected	
	1973	1974
Alaska	6	9
Arkansas		1
Florida	4	
Georgia	1	1
Illinois		2
Indiana		1
Iowa	3	1
Kansas		5
Louisiana		1
Maine	1	
Maryland	1	1
Michigan	4	3
Minnesota	2	12
Missouri	1	1
Montana		1
Nevada		1
New Jersey	1	1
North Dakota	2	
Oklahoma		1
South Carolina	1	
South Dakota	2	
Virginia	1	4
Wisconsin	6	2
Wyoming		2
TOTAL	36	50

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PCB's were estimated by comparing total peak area with Aroclor 1254 or 1260. In part of the 1974 specimens, toxaphene was estimated semiquantitatively from the area of two peaks (GC) whose retention times were 1.09 and 1.19, compared to 1.00 for DDT. The area of these peaks represents approximately 5 percent of the cut weight of the total area under the curve traced on a GC chart after an injection of standard toxaphene. Thus toxaphene is reported in terms of the two peaks and is not corrected in the original technical material.

Residues in 36 specimens (42 percent) were confirmed with an LKB 900 gas chromatograph/mass spectrometer (GC-MS). Operating procedures were described previously (*2*).

Average percentage recoveries from spiked mallard carcass tissue were DDE, 96; TDE, 103; DDT, 110; dieldrin, 101; heptachlor epoxide, 104; mirex, 106; oxychlordane, 98; *cis*-chlordane, 100; *cis*-nonachlor, 98; hexachlorobenzene, 69; and Aroclor 1254, 101. Residue levels reported here are not corrected for recovery. The lower limit of detection for all compounds was 0.05 ppm.

Results and Discussion

RESIDUES

The residues of organochlorine pesticides and PCB's in 86 specimens are summarized in Table 2. Median carcass residues of dieldrin, TDE, DDE, and PCB's showed no decrease from the years 1964–72 (*1–4*). DDE was detected in all carcasses; PCB's were found in all but two. Seventy-five carcasses contained TDE and/or dieldrin.

Three specimens had 3.9–7.9 ppm dieldrin in the brain (Table 3); based on the criteria of Stickel et al. (*5*), they probably died from pesticide poisoning. A fourth possibly died from a combination of disease and of pesticide poisoning; its brain contained 3.6 ppm dieldrin. An adult male from Maryland with 7.9 ppm dieldrin in the brain had an extensive laceration of the right auricle of the heart and resultant hemorrhage in the lungs and pericardial sac; a large clot overlaid the ventral surface of the liver. These lesions suggest that the eagle was killed by a blow to the thoracic cavity, possibly received by falling from a high perch or during flight. In all four birds, coronary fat deposits were either absent or markedly atrophied, which is

TABLE 2. *Pesticide and PCB residues in 86 bald eagles, 1973–74*

Compound	Year	Residues, ppm Wet Weight					
		Carcass			Brain		
		No. Specimens[1]	Median	Range	No. Specimens	Median	Range
p,p'-DDE	1973	36	12.0	0.15–110.0	35	3.4	0.05– 47.0
	1974	50	6.7	0.14– 85.0	46	8.6	0.05–110.0
p,p'-TDE	1973	31	1.4	0.07– 16.0	19	1.0	0.12– 3.4
	1974	44	0.47	0.05– 7.5	20	0.10	0.05– 1.8
p,p'-DDT	1973	10	0.22	0.07– 1.2	5	0.29	0.07– 0.53
	1974	18	0.12	0.05– 1.7	4	0.07	0.06– 0.16
Dieldrin	1973	34	0.74	0.06– 14.0	24	1.3	0.07– 7.9
	1974	41	0.63	0.07– 9.3	31	0.18	0.05– 4.3
Heptachlor epoxide	1973	22	0.43	0.05– 2.0	17	0.31	0.05– 0.92
	1974	32	0.20	0.05– 1.5	14	0.09	0.05– 0.57
Mirex	1973	10	0.73	0.05– 8.3	8	0.27	0.11– 1.8
	1974	18	0.25	0.07– 2.2	9	0.31	0.06– 0.90
Oxychlordane	1973	19	0.21	0.05– 1.6	12	0.32	0.12– 0.67
	1974	31	0.17	0.05– 1.0	12	0.12	0.05– 0.48
cis-Chlordane[2]	1973	25	0.45	0.08– 3.5	22	0.50	0.05– 2.7
	1974	38	0.37	0.07– 7.8	18	0.18	0.05– 2.8
cis-Nonachlor	1973	20	0.49	0.07– 2.1	16	0.29	0.05– 0.61
	1974	33	0.12	0.05– 1.3	7	0.10	0.07– 0.64
Hexachlorobenzene	1973	15	0.11	0.05– 1.2	16	0.07	0.05– 0.58
	1974	15	0.08	0.05– 0.15	5	0.07	0.05– 0.11
Toxaphene	1974	23[3]	0.28	0.05– 0.95	10	0.22	0.05– 1.2
PCB's	1973	34	23.0	1.4 –820.0	33	7.5	0.24–220.0
	1974	50	9.9	0.30–120.0	46	1.6	0.10– 98.0

[1] Number of specimens containing residues; the median is based on this number.
[2] And/or *trans*-nonachlor.
[3] Only 37 of a total of 50 specimens were analyzed for toxaphene.

TABLE 3. *Data on four suspected cases of dieldrin poisoning of bald eagles, 1973–74*

State	Year	Sex	Dieldrin Residues in Brain, ppm	Autopsy Findings [1]
Maryland	1973	M	7.9	Cardiac rupture, no fat deposits
Michigan	1973	M	3.9	Emaciation, no fat deposits
Florida	1973	F	3.6	Enteritis, no fat deposits
Illinois	1974	F	4.3	Open, no fat deposits

[1] Open = no diagnosis could be made on the basis of autopsy findings.

characteristic of pesticide poisoning. Although the body burdens of pesticide residues remained high, the percentage of eagles that died from pesticide poisoning in the 1973–74 collection (4.6 percent) decreased to less than half that of the two previous collections.

A minor 9-chlorine component of technical chlordane has been detected and confirmed by GC-MS in specimens containing appreciable chlordane residues. As with other chlordane components, the molecular ion (M), m/e 454, is weaker than the more intense M-Cl ion, m/e 419. This compound has been assigned the empirical formula $C_{11}H_7Cl_9$ by Dr. G. W. Sovocool, Health Effects Research Laboratory, Environmental Toxicology Division, Analytical Branch, U.S. Environmental Protection Agency, Research Triangle Park, N.C. It is probably the result of a side reaction between chlordene and chloroform during chlordane manufacture.

AUTOPSY

Illegal shooting remained the single most frequent cause of death (25 percent) among the eagles examined in this series (Table 4) but it accounted for a smaller percentage of the mortalities than in the two previous biennial collections (*1*,*2*).

Of seven drowned eagles, an adult male died in the Rappahannock River, Va., while fighting with another eagle. The victim had subcutaneous and deep muscle lacerations probably inflicted by the talons of the other eagle.

An old thin male eagle with multiple puncture wounds and a destroyed right eye was found floundering in the road near Phillips Landing, Va. His puncture wounds were similar to those in the Rappahannock male and in captive raptors killed during fights.

An aged emaciated female was found dead beside a road in Kansas; no evidence of trauma or poisoning was detected. There were obstructing thrombi in the major arteries of the thorax, and the eagle's death appeared to have resulted from a myocardial infarction subsequent to coronary thrombosis.

One eagle from Kodiak, Alaska, was killed when it flew into the propeller of a Coast Guard C-130; nonlethal levels of organochlorine pesticides were present in its brain and carcass.

Mortalities associated with the trapping of muskrats and mink for fur appear to have increased in 1973–74. Eagles are frequently captured in steel traps placed on muskrat houses, beaver dams, or pond dikes, and drown when they fall into the water. Six of the seven drowned eagles had such histories. Three eagles that died of fractured skull were apparently killed by fur trappers who found the birds in their traps. Other entrapped eagles are often shot.

Acknowledgments

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TABLE 4. *Probable causes of bald eagle mortality, 1973–74*

Cause of Death	No. Eagles
Shot	21
Drowning	7
Impact injuries	7
Electrocution	6
Emaciation	6
Coccidiosis	5
Dieldrin poisoning	4
Fractured skull	3
Shot; secondary bacterial infection	3
Arteriosclerosis, myocardial infarction	1
Aspergillosis	1
Asphyxiation	1
Bacterial infection	1
Euthanasia	1
Internal hemorrhage	1
Laceration; hemorrhage	1
Nephrosis	1
Multiple puncture wounds	1
Pneumonia	1
Trapping	1
Open [1]	13
Total	86

[1] No diagnosis could be made on the basis of autopsy findings or chemical analysis.

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Influence of Environmental Factors on Pesticide Levels in Sport Fish [1]

Michael James Vanderford [2] and Jerry Lee Hamelink [3]

ABSTRACT

The extent of pesticide contamination of sport fish from lakes and reservoirs in Indiana is described. Environmental and water quality factors significantly influenced the concentration of pesticides in fish. The influence of these factors was different between natural lakes and humanmade reservoirs.

Largemouth bass (Micropterus salmoides), *sunfish* (Lepomis *sp*), *and bullheads* (Ictalurus *sp.*) *were collected and analyzed for dieldrin, aldrin, DDT, DDE, heptachlor, and heptachlor epoxide. The collections and concurrent lake surveys were made during 1972–73.*

Soil and decaying plant particles appeared to influence the levels of dieldrin and Σ DDT taken up by largemouth bass. Strong correlations were observed between lake turbidity and true color and residue levels in the fish. Residue concentrations were also observed to vary between fish species, the seasons of the year, and watershed land uses.

Introduction

The survey reported here was conducted primarily to determine whether sport fish in the heavily agricultural areas of Indiana were grossly contaminated with chlorinated hydrocarbon pesticides. Specifically, the survey was designed to determine the source and causes of variations in pesticide concentrations in fish often observed in previous pesticide monitoring programs.

Materials and Methods

Fish were collected from eight natural lakes and twelve reservoirs in Indiana (Figure 1), using electro-fishing equipment and gillnets. An attempt was made to collect at least three individual bass, sunfish, and bullheads from each lake sampled. Because the age of fish influences residue levels(*1*), authors attempted to collect the same age class (3-4 years) of fish from all areas. Length, weight, sex, condition, maturity, and liver weight of each fish were recorded.

SAMPLE ANALYSIS

Fish were inspected, weighed, measured, and then frozen immediately with dry ice. Fish samples were homogenized with dry ice for fat and residue extraction (*2*). Each whole frozen fish was cut into large pieces, mixed with dry ice, and ground into a coarse meal with a Hobart food chopper. The meal and dry ice were homogenized with a high-speed Sorval Omni-Mixer to produce a free-flowing powder. The grinding and homogenization were performed in a chest

FIGURE 1. *Map of Indiana showing location of 20 lakes and reservoirs sampled*

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freezer with chilled instruments to prevent caking. Separate portions of the whole powdered fish were used for insecticide residue extraction and for determining percentages of fat and water.

The extraction and cleanup procedure employed in the insecticide residue analysis was a modification of methods described by Berg et al., 1972, developed by D. L. Ballee and R. C. Hall of the Purdue University Entomology Department (*4, 18*). Five g fish powder were extracted with 10 g cleaned anhydrous Na_2SO_4 and 40 ml glass distilled methanol in a stainless steel Sorval Omni-Mixer. The mixture and two 10-ml methanol rinses were filtered through a layer of Na_2SO_4 held in a coarse fritted glass funnel into a 125-ml Teflon separatory funnel equipped with a stopcock. The methanol solution was partitioned against three successive 50-ml volumes of hexane. The methanol portion was discarded and the hexane solution was evaporated to dryness before cleanup.

A 4-ft-by-8-mm-OD glass column was packed bottom to top with 2 g sand (45 mm), 1 g Na_2SO_4 (25 mm), 4 g coconut charcoal (310 mm), 1 g Na_2SO_4 (25 mm), and 1 g sand (22 mm). Fisher brand coconut charcoal #5-690, 50–200 mesh, benzene-cleaned and activated at 180°C (*3*), was the only charcoal suitable for the initial fractionation. The hexane-soluble residues were quantitatively transferred into the prewashed column and first eluted with 100 ml 25 percent acetone in ether (fraction A), and then eluted with 100 ml benzene (fraction B) (*3*).

Fraction A was further refined on a 2-g florisil column and successively eluted with 100 ml hexane (fraction A-1) and 100 ml 25 percent ether in hexane (fraction A-2) (*14*). Fraction B was fractionated on a 3-g silica-gel column first eluted with 230 ml hexane (fraction B-1) which contained all PCB's, followed by 40 ml benzene (fraction B-2) (*8,10*). All fractions A–2 and B–2 containing dieldrin and ΣDDT residues, respectively, were analyzed by gas chromatography (GC) with either a Tracor MT-220 or a Packard 7000 series GC equipped with NI^{63} electron-capture detectors and 6-ft-by-2-mm-ID glass columns packed with 3 percent OV-1 or OV-17 on 100–120 mesh Gas-Chrom Q. No values reported are corrected for efficiency, which was essentially 100 percent, and no interferences were detected in the solvent blanks run with each series of 10 samples.

Results

Sport fish collected from Indiana lakes and reservoirs during 1972–73 were contaminated with pesticide residues (Table 1). Several environmental factors significantly influenced the concentration of pesticide residues found in the fish. Of the seven pesticides monitored, only dieldrin, DDT, and DDE were detected above trace levels. The pesticide residue levels varied significantly among groups of samples, but these variations were correlated with the species of fish, season of the year, watershed land use, and turbidity and true color of the water. The correlations observed with turbidity and true color were positive in reservoirs and negative in natural lakes. However, no correlations existed between pesticide concentrations and any of the other limnological or physiological parameters measured.

Authors found a distinct difference in pesticide levels among different fish species from the same lake (Figure 2). Largemouth bass consistently had higher levels of pesticide residues than had species of sunfish (*Lepomis*). The levels in *Lepomis* were often undetectable. A reason for the relatively lower levels in sunfish was not apparent. However, Henderson et al. also observed this same species difference in Iowa reservoirs (*7*). Although bullheads consistently had measurable residue levels, they could not be obtained in sufficient numbers or from enough lakes to make a statistically valid analysis. Therefore, comparisons between sites and seasons were based solely on data from largemouth bass.

Dieldrin residue levels were relatively high in bass from the flood control reservoirs (Figure 3; Table 1) which drain large areas of corn cropland treated with aldrin (*9,16,17*). Conversely, dieldrin levels were undetectable in samples from Monroe Reservoir and several other smaller reservoirs in southern Indiana which have virtually no corn cropland in their watersheds (*9*). Dieldrin was also absent from Shafer Reservoir in northern Indiana. The watershed of Shafer was not treated with aldrin because it posed a contamination threat to the dairy industry in the basin (personal communication: F. T. Turpin, 1973, Entomology Department, Purdue University, West LaFayette, Ind. 47907).

Dieldrin was rarely detected in fish from natural lakes (Figure 3; Table 1) found only in the northern region of the State where fruit orchards predominate (Figure 1). However, fish from the natural lakes contained significantly higher levels of ΣDDT than did fish from reservoirs (Figure 4).

ΣDDT residue levels in the fish from the natural lakes were negatively correlated to the trophic state of the lake sampled (Figure 5). High ΣDDT residue levels were found in bass from clear, natural lakes which had low levels of turbidity and true color. Conversely, hyper-eutrophic lakes such as Sylvan and Cedar, which had high levels of turbidity and color primarily due to abundant planktonic algae, contained fish with low residue levels (Figure 4).

In contrast to the natural lakes, positive correlations were observed between the trophic state and dieldrin residues in fish from the flood control reservoirs, as demonstrated in Figure 6. (Data on turbidity and true color were not available for two corn crop area reservoirs.) High levels of diel-

TABLE 1. *Pesticide residues in largemouth bass from 20 lakes and reservoirs in Indiana*

Lakes	No.	Residues, ppm wet weight				Turbidity	Color
		Dieldrin		ΣDDT			
		Avg.	SD	Avg.	SD		
Bass	3	0.00	0.00	0.08	0.02	20	18
Cedar	4	0.02	0.014	0.05	0.024	20	25
Crooked	3	0.036	0.017	0.143	0.037	0.28	9
Maxinkukee	3	0.013	0.008	0.157	0.051	2.3	7
Olin	3	0.03	0.005	0.127	0.032	1.1	12
Oliver							
summer '72	2	0.025	0.005	0.112	0.018	1.3	7
fall '72	4	0.00	0.00	0.03	0.008	1.4	7
spring '73	3	0.02	0.015	0.04	0.015	4.5	—
Sylvan							
summer '72	2	0.00	0.00	0.03	0.01	10	25
fall '72	3	0.00	0.00	0.02	0.005	15	30
spring '73	3	0.01	0.00	0.03	0.02	7	—
Wawasee	4	0.01	0.00	0.10	0.04	8	8
Reservoirs							
Cataract	3	0.137	0.092	0.05	0.014	1.25	10
Dogwood	4	0.01	0.00	0.03	0.015	2.5	7
Eagle Creek	5	0.078	0.046	0.036	0.007	—	—
Huntington	2	0.14	0.00	0.035	0.01	44	45
Mississinewa	3	0.075	0.035	0.03	0.00	—	—
Monroe							
spring '72	5	0.00	0.00	0.054	0.027	2.0	8
summer '72	4	0.00	0.00	0.088	0.009	2	8
fall '72	3	0.00	0.00	0.05	0.014	12.3	9
spring '73	2	0.01	0.00	0.01	0.01	7	—
Raccoon	3	0.06	0.06	0.046	0.025	2	13
Salamonie							
summer '72	3	0.23	0.036	0.066	0.017	51	80
fall '72	3	0.14	0.095	0.04	0.017	30	90
winter '73	3	0.09	0.061	0.02	0.00	141	400
spring '73	3	0.23	0.236	0.06	0.018	32	—
Shafer	2	0.00	0.00	0.02	0.00	24.9	30
Shakamak	2	0.00	0.00	0.06	0.01	2.3	15
Starve Hollow	3	0.01	0.005	0.05	0.015	2.6	15
Sullivan	3	0.00	0.00	0.05	0.02	5.5	10

drin residue were found in bass from very turbid reservoirs with high true color values, typified by Salamonie Reservoir (Table 1; Figure 3). Succeedingly lower levels of dieldrin residues were consistent with lower levels of turbidity and true color in the reservoirs.

A strong seasonal trend was also observed in the fish sampled both from the natural lakes and the reservoirs (Figure 7). Pesticide levels were high in the summer, but declined during fall and winter.

Discussion

Sediment particles appear to influence significantly the concentration of pesticide contaminants absorbed by fish when residues reach a lake or reservoir. This was partly substantiated by the correlations observed between the dieldrin levels in fish from reservoirs versus the turbidity and true color levels of the water in which the fish lived (Figure 6). The level of pesticide contaminants found in the fish increased as the level of eroded sediment and washed-in debris increased.

A strong seasonal variation in residue concentrations was observed in Salamonie Reservoir (Figure 7). This is a flood control reservoir located in a watershed in northern Indiana which is about 75 percent farmland. Salamonie Reservoir and others more closely resemble wide places in a river than they do lakes because they are continuously flushing. Presumably, the spring rains washed soil particles and decaying plant matter from the cultivated fields, which received spring treatments of aldrin, into the reservoir, introducing large quantities of the recently applied contaminants. The actual concentration in the water would be a function of the amount of pesticide in the sediment and debris washed into the reservoir and the volume of water participating in the exchange (*6*). The fish would subsequently take up the contaminants in proportion to the concentration available in the water (*5*).

The contaminant concentration in the fish would then be expected to decline throughout the growing season for several reasons. Vegetative cover would reduce soil erosion

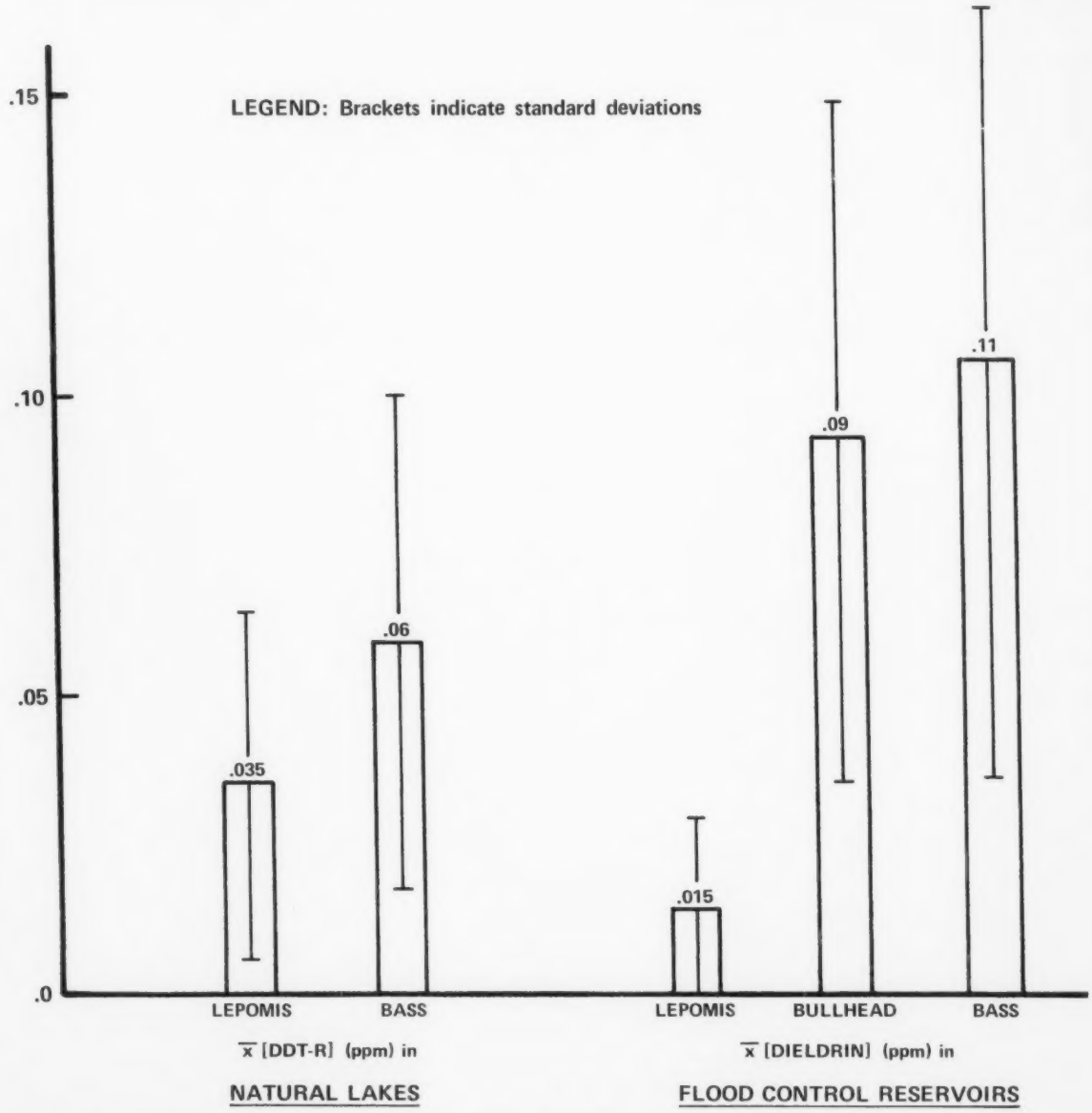

FIGURE 2. *Mean pesticide levels in three fish species combined from eight natural lakes and from six reservoirs in corn crop areas, summer 1972*

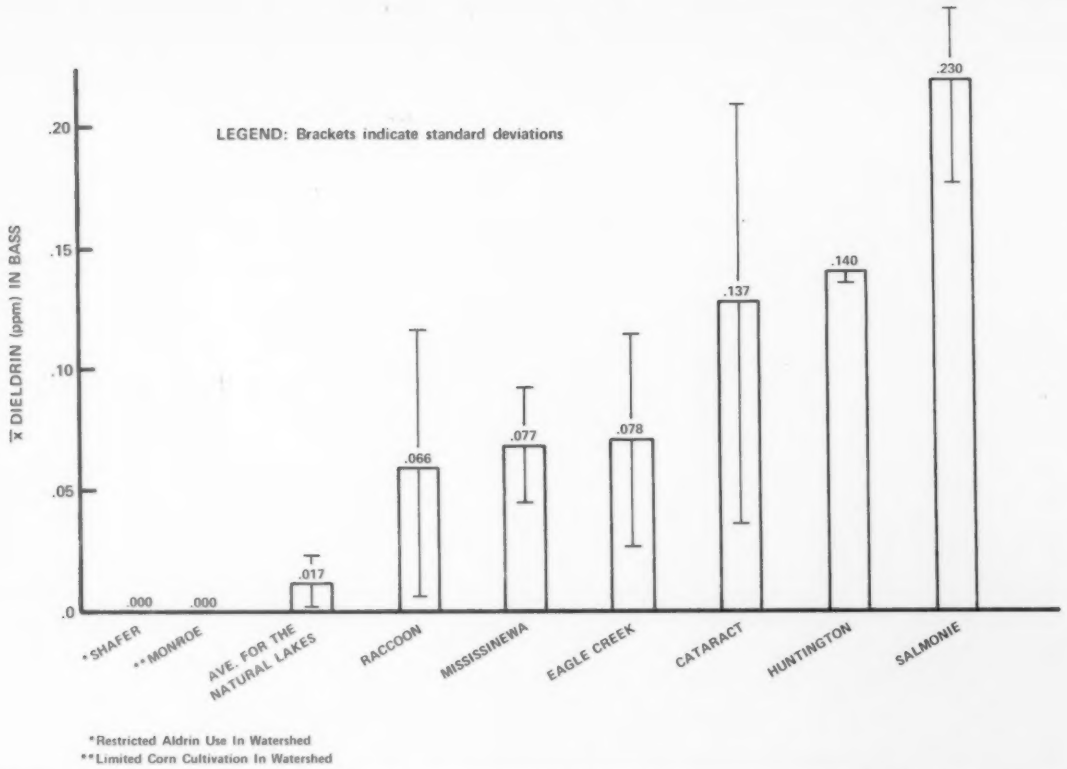

FIGURE 3. *Mean dieldrin levels in bass collected from six reservoirs in areas of heavy corn cultivation and aldrin use, summer 1972*

into the reservoirs. The soil particles washed into the reservoir would contain less residue. The concentration already in the reservoir would be continuously diluted by the flushing of the reservoir itself. The concentration in the fish would decline as the concentration in the water declined (*5*).

The data from the natural lakes sampled support the idea that sediments and vegetative debris have a major influence on pesticide levels in fish. In the natural lakes there was a negative correlation between the contaminant levels in fish and the associated turbidity and true color. The soil and plant particles definitely influenced residue levels in the lakes as well as in the reservoirs, but in the lakes, allochthonous particles reduced residue concentrations.

The watersheds of the natural lakes sampled are used extensively for orchard cultivation, but are no longer treated with DDT (*15*). Therefore, any soil and plant particles in runoff received by the lakes should not contain significant ΣDDT residues. Rather, any recently eroded sediment and washed-in debris should adsorb residues remaining in the lake water from years past. Hence the fish would lose residues to the water, in an equilibrium shift, as the contaminant in the water was reduced. Thus as the amount of turbidity and true color increased, the concentration of residues in the fish decreased (Figure 5). Seasonal fluctuations of the pesticide levels in fish from the natural lakes were also consistent with this concept.

A definite seasonal variation was observed in Oliver Lake, a small natural lake surrounded by summer homes and limited agriculture. The ΣDDT levels in the fish in Oliver were reduced from summer to fall and appeared to increase in the early spring. As previously discussed, these variations would not be caused by seasonal introductions of DDT-laden sediment. Rather, with no new introductions of a pesticide and minimal erosion from the small watershed, this variation in a natural lake would be explained by spring turnover and subsequent sedimentation during thermal stratification.

Spring turnover would reintroduce residue-laden bottom sediment to the water column, thereby making the pesticide residues more available to the water and subsequently to the fish (*5*). Stratification would permit these sediments, plus any newly generated or introduced sediment from the watershed, to settle onto the lake bottom. The particles

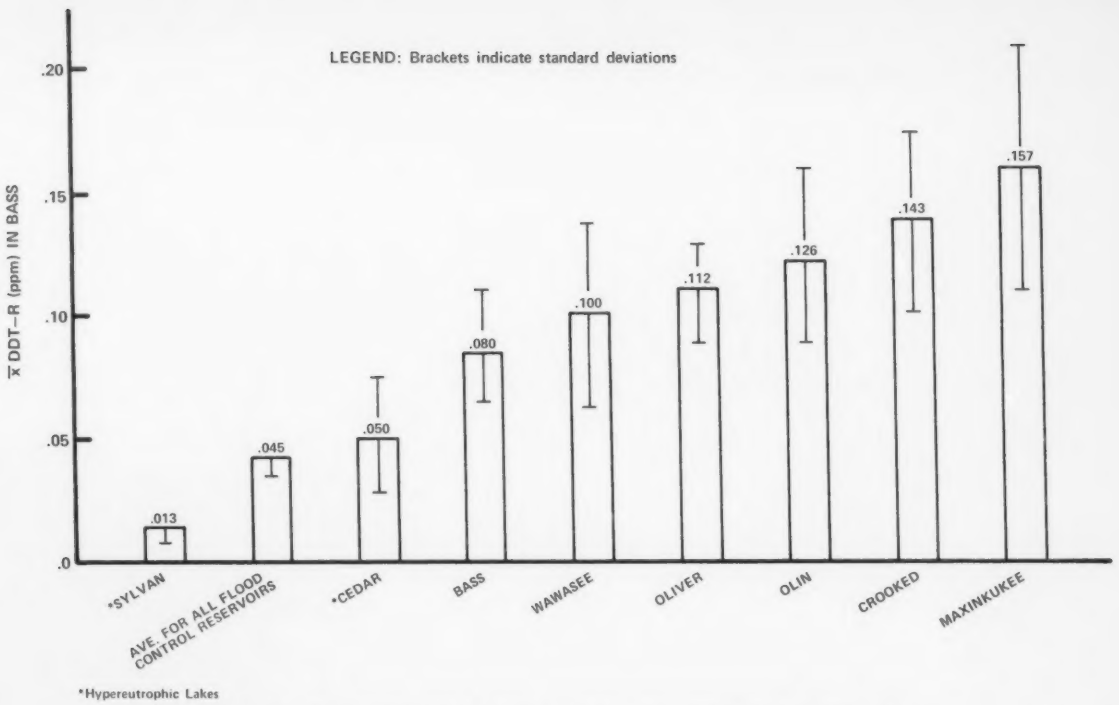

FIGURE 4. *Mean ΣDDT levels in bass collected from natural lakes in summer 1972*

would presumably adsorb residues from the water column which would subsequently reduce residue levels in the fish. Fall turnover probably would not have the same effect as the spring turnover because sedimented organic particles, especially algae, would not have decayed enough to release adsorbed pesticides. Also, the low fall/winter temperatures would promote adsorption rather than desorption (*6*).

The results which authors observed in both natural and humanmade lakes demonstrate that the concentrations of turbidity and true color significantly influence the level of pesticide residues in fish. The contrasting correlations observed between the parameters in natural lakes and reservoirs, and the seasonal variations observed in both, support this contention. Soil and decaying plant particles will cause pesticide residue levels in fish either to increase or decrease according to the amount of residue adsorbed to allocthonous particles and the residue concentration already in the water. The soil and plant particles apparently affect the residue concentration equilibrium between water and the fish.

Acknowledgments

Barbara Macy, a technician in the Purdue University Entomology Department, and Dr. Ronald Waybrant, presently with the Michigan Department of Natural Resources, were essential in training Mr. Vanderford in the chemical and analytical techniques used in this research. Figures were prepared by Michael C. Anderson, artist-illustrator, Control Data Corporation, Bloomington, Minn.

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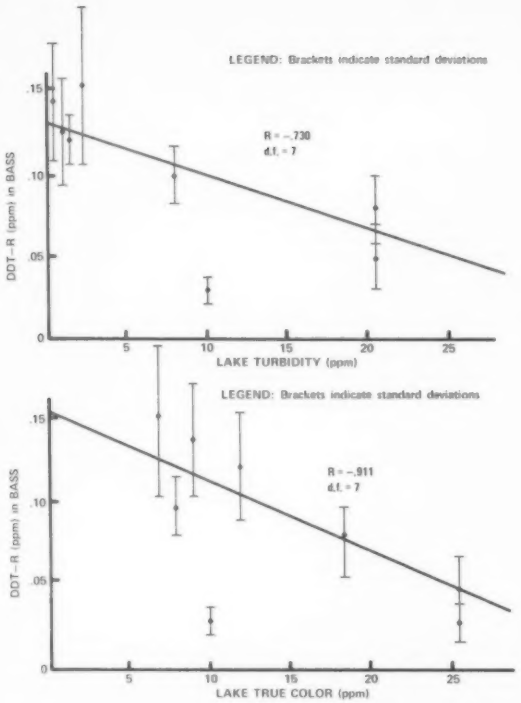

FIGURE 5. *Negative correlation between ΣDDT levels in bass from the natural lakes versus concentration of turbidity and true color in lakes at time of sampling*

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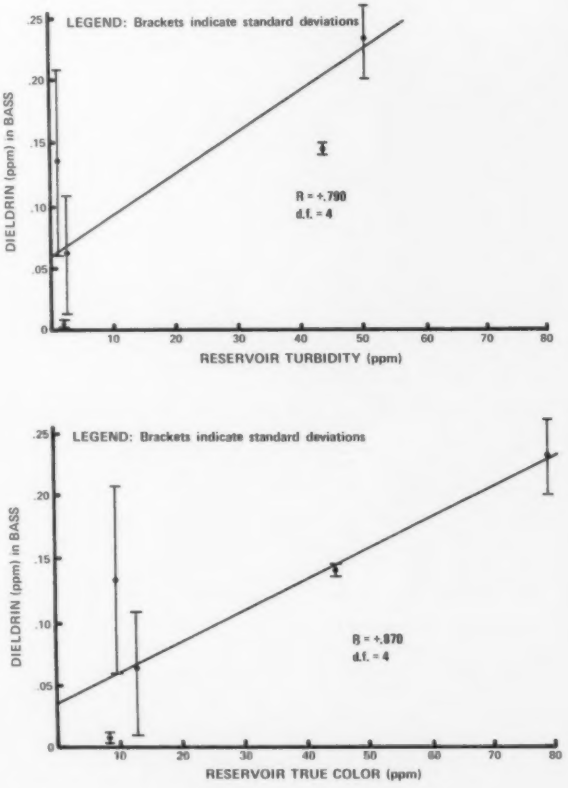

FIGURE 6. *Positive correlation between mean dieldrin levels in bass from Monroe Reservoir and four reservoirs in corn crop areas versus concentration of turbidity and true color in reservoirs at time of sampling.*

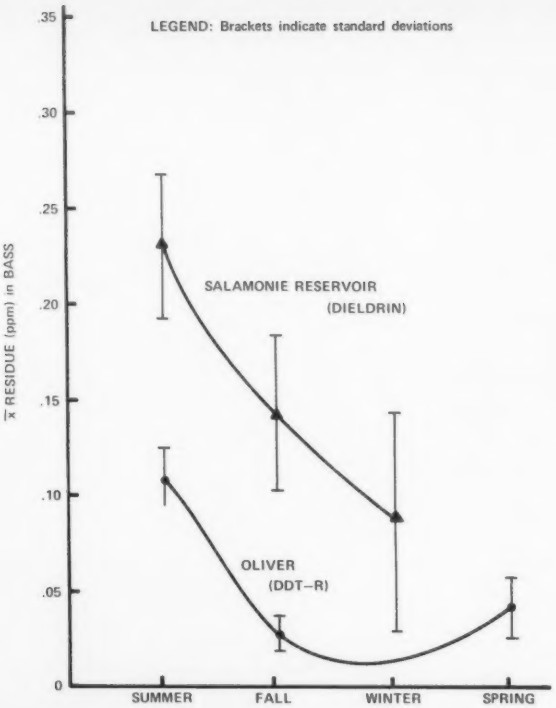

FIGURE 7. *Seasonal change in mean pesticide levels in bass from Oliver Lake and Salamonie Reservoir sampled seasonally, 1972–73*

GENERAL

Mirex Residues in Nontarget Organisms After Application of 10-5 Bait for Fire Ant Control, Northeast Florida—1972–74[1]

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ABSTRACT

The 10–5 bait formulation of mirex insecticide was applied to a 20,000-acre area of northeast Florida. For 24 months after application, samples of a wide variety of fauna were collected and analyzed for mirex content.

Insects accumulated mirex to the greatest extent in the first 6 months after application; most residues had decreased greatly by 12 months. Other invertebrates showed low mirex levels during the first 9 months after application and none after 12 months. Fish possessed low levels of insecticides for 9 months; amphibians showed mirex residues for 12 months after application. In general, reptiles had low levels throughout the 24-month period and mammals had higher levels, particularly in fat tissues. Birds consistently had low to moderate mirex levels. After a single application of 10-5 mirex bait, only relatively low levels of insecticide were detected in exposed fauna. After 24 months, mirex was found infrequently and at low levels.

Introduction

Mirex is the only insecticide approved for area-wide control of the red and black imported fire ants, *Solenopsis invicta* and *Solenopsis richteri*, in the southeastern United States. This chemical has been formulated and applied primarily as the 4X bait composed of 0.3 percent mirex, 14.7 percent soybean oil, and 85 percent corncob grits. Recently, a new 10-5 bait formulation containing 0.1 percent mirex has been described (*2*). This formulation was designed to make more of the toxicant available to the fire ant and leave less behind which might contaminate nontarget organisms and other elements of the environment.

Mirex applications have been shown to cause pesticide residue accumulations in the nontarget species (*1,3–10,12,13*). Most of these studies used the 4X bait formulations although a recent study by some authors of the present paper employed several bait formulations (*12*).

Applications of the 10-5 formulations have been as effective in controlling the fire ants as was the 4X formulation (*2*). No residue data in nontarget organisms have been reported after use of the 10–5 formulation.

This paper reports the results of a 2-year monitoring study of mirex in diverse animals after application of the new 10-5 bait formulation in the animals' habitat.

Methods

EXPERIMENTAL SITE

The experimental site consisted of approximately 20,000 acres (8000 ha.) in Duval and St. Johns Counties near Jacksonville, Fla. Based upon available records, no mirex had been previously applied to this area.

MIREX APPLICATION

Mirex was applied as a 0.1 percent bait consisting of 85 percent corncob grits, 14.9 percent once-refined soybean oil, and 0.1 percent mirex. It was prepared by Allied Chemical Corporation according to the procedures of Banks et al. (*2*).

The bait was applied at a rate of 1.0 lb/acre (1.12 kg/ha.) using a single-engine aircraft at an altitude of 150 feet (45.7 m). The aircraft was guided by kytoons and the bait was distributed using a gravity-fed Piper Pawnee dispersal system. Personnel of the Division of Plant Industry,

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Florida Department of Agriculture and Consumer Services, supervised bait application.

SAMPLE COLLECTION

The sample collection dates are listed in Table 1. Invertebrates and small vertebrates were collected in pitfall traps (*11*) which contained small open jars of technical chloropyrifos as a killing agent. Twenty traps were set in a grid pattern at each of eight locations, two in each of four types of habitat: pasture, pine forest, hardwood forest, and adjacent to swamps. Hand collections were made to supplement pitfall trap collections whenever possible.

TABLE 1. *Dates of mirex application and sampling of nontarget organisms, northeast Florida—1972–74*

Pretreatment samples	May 22–June 7, 1972
Bait applied	July 11–12
1-month posttreatment samples	August 4–11
3-month posttreatment samples	October 6–17
6-month posttreatment samples	January 8–29, 1973
9-month posttreatment samples	April 9–30
1-year posttreatment samples	July 9–23
18-month posttreatment samples	January 14–18, 1974
2-year post-treatment samples	August 23–30

Aquatic invertebrates, amphibians, and reptiles were collected by hand. Fish were stunned with an electric shocker or rotenone prior to collection. Mammals and birds were trapped, netted, or shot.

Insectivorous, omnivorous, and predatory brids and mammals were monitored. Certain species were chosen because of their availability and restricted movement, because au-

TABLE 2. *Animals analyzed for mirex residues after single treatment of 10-5 bait, Dee Dot Ranch, Fla.—1972 -74*

Scientific Name	Common Name
Insects	
Pictonemobius ambitiosus	ground cricket
Gryllus rubens	southern field cricket
G. firmus	sand cricket
G. fultoni	southern wood cricket
Miogryllus verticallis	strip-headed cricket
Scapteriscus vicinus	changa
S. acletus	southern mole cricket
Ceuthophilus spp.	camel cricket
Parcoblatta spp.	wood cockroach
Cariblatta lutea	small yellow cockroach
Eurycotis floridana	stinking cockroach
Pycnoscelus surinamensis	Surinam cockroach
Gonatista grisea	grizzled mantis
Euborellia annulipes	ringlegged earwig
Labidura riparia	riparian earwig
Marava pulchella	handsome earwig
Prosapia bicincta	twolined spittlebug
Plecia nearctica	lovebug
Spiders	
Latrodectus mactans	black widow spider
Crustaceans	
Uca sp.	fiddler crabs
Mollusks	
Crassostrea virginica	American oyster
----	(mixed unidentified freshwater snails)
Amphibians	
Bufo terrestris	southern toad
Bufo quercicus	oak toad
Rana heckscheri	river frog
Rana sphenocephala	leopard frog
Rana catesbeiana	bull frog
Rana areolata	gopher frog
Rana sp	tadpoles
Gastrophryne carolinensis	narrow-mouth toad
Scaphiopus holbrooki	spadefoot toad
Hyla cinerea	greentree frog
Hyla femoralis	pinewoods tree frog
Reptiles	
Alligator mississippiensis	American alligator
Trionyx ferox	soft-shelled turtle
Kinosternon subrubrum	common mud turtle
Sceloporus undulatus	fence lizard
Scincella laterale	brown skink
Cnemidophorus sexlineatus	six-lined racerunner
Ophisaurus	legless glass lizard
Coluber constrictor priapus	southern black racer
Thamnophis sirtalis	garter snake
Thamnophis sauritus sackeni	ribbon snake

Scientific Name	Common Name
Worms	
----	mixed unidentified earthworms
Fish	
Gambusia affinis	eastern mosquito fish
Lepomis macrochirus	bluegill
Lepomis microlophus	redear sunfish
Lepomis gulosus	warmouth
Micropterus salmoides	largemouth bass
Notemigonus crysoleucas	golden shiner
Erimyzon sucetta	lake chubsucker
Anguilla rostrata	American eel
Ictalurus nebulosus marmoratus	brown bullhead
Lepisosteus platostomus	shortnose gar
Mammals	
Didelphis virginiana	opossum
Procyon lotor	raccoon
Dasypus novemcinctus	armadillo
Lasiurus borealis	red bat
Nycticeius humeralis	evening bat
Sylvilagus palustris	marsh rabbit
Cryptotis parva	least shrew
Birds	
Anhinga anhinga	anhinga
Buteo jamaicensis	red-tailed hawk
Colinus virginianus	bobwhite
Gallinula chloropus	common gallinule
Melanerpes carolinus	red-bellied woodpecker
Sayornis phoebe	eastern phoebe
Cyanocitta cristata	blue jay
Corvus brachyrhynchos	common crow
Parus carolinensis	carolina chickadee
Sitta pusilla	brown-headed nuthatch
Troglodytes aedon	house wren
Turdus migratorius	robin
Catharus guttata	hermit thrush
Sialia sialis	eastern bluebird
Dendroica pinus	pine warbler
Dondroica coronata	myrtle warbler
Dendroica palmarum	palm warbler
Setophaga ruticilla	American redstart
Agelaius phoeniceus	red-winged blackbird
Quiscalus quiscula	common grackle
Pipilo erythrophthalmus	rufous-sided towhee
Melospiza georgiana	swamp sparrow
Melospiza melodia	song sparrow
Spizella passerina	chipping sparrow
Spizella arborea	tree sparrow
Passerculus sandwichensis	savannah sparrow
Ammodramus henslowii	Henslow's sparrow
Amiophila aestivalis	Bachman's sparrow

thors wanted a cross section of the fauna. Stomach contents of some birds and mammals were analyzed for an indication of dietary habits.

A complete listing of animal species collected is in Table 2.

MIREX ANALYSIS

Sample preparation, extraction, extract cleanup, mirex identification, and quantification have been described by Wojcik et al. (*12*). Mirex residues, reported except as noted in ppm fresh-weight (as the sample was received for analysis), were not corrected for recoveries less than 100 percent.

Results and Discussion

Results are often presented as values measured in composite samples. In Table 3, for example, at the one-month sampling of adult ground crickets, a composite of eight individuals collected in one location had no detectable mirex and another composite of three individuals possessed 0.09 ppm. Occasionally, very high levels were detected in some specimens: for example, one earwig collected at the 3-month sampling listed in Table 4. These values are presented for informational purposes and should not be considered significant.

Mirex residues detected in crickets are shown in Table 3. None of the pretreatment samples contained detectable mirex. By 1 month after application, 24 percent of the samples did possess low levels (0.02–0.37 ppm), but after 3 months the percentage of samples showing mirex was the highest of the entire experimental period: 33 percent. Certain species sampled at 3 and 6 months possessed the highest mirex levels detected during the 24-month period. By 6 months after treatment, the proportion of samples containing mirex had dropped to 15 percent and remained relatively constant through the remainder of the 24-month collection period. The mirex levels detected after 6 months

TABLE 3. *Mirex residues in crickets from Dee Dot Ranch after single treatment of 10-5 bait, 1972–74*

	Residues, ppm Fresh Weight [1]					
Pretreatment	Posttreatment					
	1 month	3 months	6 months	9 months	1 year	2 years
Adult Ground Crickets						
ND (104)	ND (8) 0.09 (3)	ND (25)	ND (13) 0.49 (3) 3.52 (3)	ND (17)	ND (167) 0.04 (4)	ND (23) 0.74 (5)
Nymphal Ground Crickets						
ND (36)	ND (1)	ND (24) 1.54 (7) 3.22 (3)	ND (6)	ND (9)	ND (16) 1.38 (8)	
Adult Southern Field Crickets						
ND (16)	ND (46)	ND (9)	ND (12)	ND (13)	ND (56)	ND (29)
Adult Sand Crickets						
ND (3)	0.09 (2)	ND (9)	ND (1)		ND (1)	ND (6)
Adult Southern Wood Cricket						
ND (1)		ND (4)	ND (1)		ND (1)	ND (2)
Adult Stripe-headed Crickets						
ND (19)	ND (7) 0.13 (3) 0.32 (2) 0.37 (1)				ND (24) 0.02 (4)	ND (1)
Nymphal Stripe-headed Crickets						
ND (23)	ND (1) 0.02 (4)	ND (2) 0.11 (17) 0.61 (8)		ND (4)	ND (1)	ND (1)
Adult and Nymphal Changa						
ND (27)	ND (2) 0.03 (2)	ND (4)		ND (3) 0.13 (4)	ND (9) 0.03 (2)	
Adult and Nymphal Southern Mole Cricket						
ND (2)						ND (1)
Nymphal Camel Crickets						
ND (9)	0.08 (1) 0.12 (2)	ND (3)	ND (2)	ND (3)	ND (1) 0.02 (1)	ND (3) 0.03 (3)

NOTE: ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent number of specimens in pooled samples.
[1] Fresh weight = as received for analysis. Specimens were not dried.

were substantially reduced, ranging from 0.03 to 0.74 ppm at the 24-month sampling interval. A large percentage of the residues detected were in the ground cricket (*Pictonemobium ambitiosus*) and all the high mirex levels detected were in this species.

Table 4 presents insecticide residues in miscellaneous insects. No mirex was detected in pretreatment samples. Sixty-one percent of the 1-month posttreatment samples contained mirex; one individual had 4.10 ppm. At 3 months, one earwig possessed 19.79 ppm. Sixty other samples had no detectable residue. At 6 months and 12 months 54 percent and 62 percent of the samples had residues: 0.04–7.78 ppm at 6 months and 0.02–1.14 ppm at 12 months. The 7.78 ppm was in five earwigs. No mirex was detected in the 9-month samples. At 24 months, 16 percent of the miscellaneous insects contained mirex at levels ranging from 0.58 to 0.79 ppm.

Residue data from a few miscellaneous invertebrates appear in Table 5. Pretreatment fiddler crabs (*Uca* sp.), which constituted 33 percent of the miscellaneous invertebrate samples, contained 0.33 ppm mirex. Posttreatment percentages of samples containing mirex were 30, 10, 30, 2, 17, and 0 percent for 1, 3, 6, 9, 12, and 24 month samples, respectively. Spiders consistently had detectable mirex levels which ranged from 1.30 ppm in a 1-month sample to 0.06 ppm in a 9-month sample.

Mirex levels in fish are listed in Table 6. Forty-five mosquito fish, 54 percent of the entire fish sample, contained an average of 0.33 ppm mirex before application of the insecticide. One month after application 27 mosquito fish, 44 percent of the 1-month sample, contained an average of 0.08 ppm mirex. At 3, 6, and 9 months, the proportion of samples containing any insecticide ranged from 3 to 13 percent and the levels of mirex, when found, were

TABLE 4. *Mirex residues in insects from Dee Dot Ranch after single treatment of 10-5 bait, 1972–74*

	Residues, ppm Fresh Weight [1]					
Pretreatment	Posttreatment					
	1 month	3 months	6 months	9 months	1 year	2 years
Adult and Nymphal Wood Cockroaches						
ND (8)	ND (5) 4.10 (1)	ND (12)	ND (7) 0.22 (3) 0.04 (22)	ND (20)	ND (6) 0.02 (5) 0.02 (9)	ND (6) 0.58 (5)
Adult and Nymphal Small Yellow Cockroaches						
ND (2)	ND (1)	ND (1)	ND (1)	ND (6)	ND (6)	ND (1)
Adult Dark Wood Cockroaches						
				ND (2)	0.39 (1)	
Adult Stinking Cockroach						
					0.51 (1)	
Adult Surinam Cockroach						
					ND (1)	
Adult Grizzled Mantis						
					0.06 (1)	
Adult and Nymphal Ringlegged Earwigs						
ND (15)	0.48 (10)	ND (41) 19.79 (1)	ND (7)	ND (25)		0.79 (4)
Adult Riparian Earwigs						
					ND (1)	ND (1)
Adult Handsome Earwigs						
			ND (11) 7.78 (5)			
Adult Twolined Spittlebugs						
ND (3)	ND (1)	ND (6)			ND (4) 0.64 (8) 1.14 (9)	ND (1)
Adult Lovebugs						
						ND (39)

NOTE: ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent number of specimens in pooled sample.
[1] See footnote, Table 3.

TABLE 5. *Mirex residues in miscellaneous invertebrates from Dee Dot Ranch after single treatment of 10-5 bait, 1972–74*

Pretreatment	Residues, ppm Fresh Weight [1]					
	Posttreatment					
	1 month	3 months	6 months	9 months	1 year	2 years
Black Widow Spiders						
	1.30 (2)	ND (2) 0.16 (3) 0.49 (7)	0.17 (6)	ND (3) 0.06 (2)		ND (1)
Oysters						
ND (15)	ND (15)	ND (20)	ND (25)	ND (25)	ND (25)	ND (25)
Fiddler Crabs						
0.03 (23)	ND (25)	ND (19)		ND (25)	ND (25)	ND (25)
Miscellaneous Fresh Water Snails						
ND (15)		ND (20)		ND (25)	ND (25)	ND (26)
Earthworms						
ND (16)	0.07 (15)	ND (25)	ND (25)	ND (26)	0.02 (15)	ND (25)

NOTE: ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent number of specimens in pooled sample.
[1] See footnote, Table 3.

TABLE 6. *Mirex residues in fish from Dee Dot Ranch after single treatment of 10-5 bait, 1972–74*

Pretreatment	Residues, ppm Fresh Weight [1]						
	Posttreatment						
	1 month	3 months	6 months	9 months	1 year	18 months	2 years
Eastern Mosquito Fish							
0.33 (45)	0.08 (27)	ND (45)	ND (35)	ND (39)	ND (50)	ND (46)	ND (50)
Bluegills							
ND (16)	ND (12)	ND (40)	ND (30)	ND (35)	ND (17)	ND (25)	ND (35)
Redear Sunfish							
ND (3)	ND (2)	ND (9) 0.21 (1)	ND (25)	ND (20)	ND (7)	ND (2)	ND (14)
Warmouth							
ND (1)	ND (3)	ND (4) 0.25 (1)	ND (7)	0.01 (4)			ND (5)
Largemouth Bass							
ND (6)	ND (6)	ND (1)	ND (27)	ND (35)	ND (23)	ND (15)	ND (30)
Golden Shiners							
	ND (3)	ND (4)	ND (11)	ND (9)	ND (2)	ND (7)	ND (30)
Lake Chubsuckers							
			ND (3)	ND (10)		ND (9)	ND (10)
Eels							
ND (8)		ND (2) 0.07 (1)	0.19 (6)	0.13 (18)	ND (16)	ND (14)	
Brown Bullhead							
ND (5)	0.02 (9)				ND (2)	ND (9)	ND (5)
Shortnosed Gars							
							ND (3)

NOTE: ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent numbers of specimens in pooled sample.
[1] See footnote, Table 3.

0.01–0.25 ppm. After the 9-month sample, no insecticide was detected in fish.

Mirex residues in amphibians are shown in Table 7. Four oak toads contained an average of 0.42 ppm mirex before treatment. Only one other sample in this group had any trace of the insecticide. One month after treatment, 80 percent of the amphibians contained mirex ranging from 0.02 to 0.78 ppm. In general, the percentage of samples containing mirex decreased with time and the levels followed a similar pattern. Mirex was not detected in amphibians 24 months after application.

Mirex levels found in reptiles are listed in Table 8. Although few individuals were sampled, some observations can be made. Only one of six pretreatment samples possessed detectable mirex: 0.01 ppm. From 1 through 9 months after application, more than 85 percent of the samples possessed mirex ranging generally from 0.02 to 0.78 ppm; one alligator fat sample contained 1.19 ppm. At 24 months, the incidence of detectable mirex had dropped to 20 percent of the samples and the levels ranged from 0.01 to 0.06 ppm.

Mirex residues in mammals are shown in Table 9. As with reptiles, only a few individuals were sampled. Prior to treatment, 44 percent of the individuals contained low mirex levels, all below 0.07 ppm. All but one sample contained detectable mirex after application. Insecticide levels varied with time and animal tissue and had an overall range

TABLE 7. *Mirex residues in amphibians from Dee Dot Ranch after single treatment of 10-5 bait, 1972–74*

	Residues, ppm Fresh Weight [1]					
Pretreatment	Posttreatment					
	1 month	3 months	6 months	9 months	1 year	2 years
Southern Toads						
ND (4) 0.03 (1)			ND (1)	0.09 (1)		
Oak Toads						
ND (7) 0.42 (4)	0.78 (4)	0.11 (11)	1.01 (1) 0.20 (1)	0.15 (1)	0.04 (3)	ND (3)
River Frogs						
ND (7)	0.28 (3) 0.02 (12)	ND (5)	ND (2)	ND (5) [a] ND (12) [b] 0.26 (4) [b]	ND (6)	
Leopard Frogs						
ND (5)	ND (1) 0.04 (1)	ND (1) 0.13 (1)		0.01 (3)		
Bull Frogs						
ND (5)	0.04 (8)	ND (3) 0.02 (1)		ND (7)		ND (4)
Gopher Frogs						
	0.14 (4)					
***Rana* sp Tadpoles**						
	ND (7)	ND (12)	ND (10)			
Narrow-mouth Toads						
ND (38)	0.52 (3)	0.09 (3)	0.17 (3)	0.01 (1)	0.06 (1)	ND (10)
Spadefoot Toads						
ND (5)	ND (1)		0.02 (1) 0.02 (1)		0.05 (3)	ND (1)
Green Tree Frog						
	ND (1)	ND (1)		ND (1)		
Pinewoods Tree Frog						
	0.08 (2)		ND (1)			

NOTE: ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent numbers of specimens in pooled samples.
[a] mature adults
[b] recently metamorphosed adults
[1] See footnote, Table 3.

TABLE 8. *Mirex residues in reptiles from Dee Dot Ranch after single treatment of 10-5 bait, 1972–1974*

	Residues, ppm Fresh Weight [1]							
	Pretreatment	Posttreatment						
		1 month	3 months	6 months	9 months	1 year	18 months	2 years
Alligator								
Brain	ND [c]					ND [c]		0.04 [c]
Fat	ND [c]	0.27 [c]	1.19 [c]					0.06 [c]
Liver	ND [c]	ND [c]	ND [c]			ND [c]		0.04 [c]
Muscle	ND [c]	ND [c]	0.02 [c]			ND [c]		0.04 [c]
Stomach Content	0.01 [c]	0.04 [c]	0.13 [c]					
Whole		0.03 [d]						
Soft Shell Turtle								
Fat & Eggs	ND (1)				ND (1)			ND [c]
Whole								0.01 [c]
Mud Turtle								
			ND (1)					
			0.03 (1)					
Fence Lizards								
	ND (1)	0.05 (1)	0.19 (1)	0.12 (1)	0.08 (4)	0.04 (1)	0.30 (3)	ND (7)
			0.51 (1)	0.18 (1)				
Brown Skink								
					0.11 (2)			
5-lined Race Runner								
								ND (1)
Legless Glass Lizard								
	ND (1)				ND (1)			
Black Snake								
	ND (1)				0.06 (1)		0.04 (1)	
Garter Snake								
	ND (1)							
Ribbon Snake								
					0.04 (1)			

NOTE: ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent numbers of specimens in pooled samples.
Residues followed by different letters represent subsamples of different specimens from a sample collection period.
[1] See footnote, Table 3.

TABLE 9. *Mirex residues in mammals from Dee Dot Ranch after single treatment of 10-5 bait, 1972–74*

	Residues, ppm Fresh Weight [1]							
	Pretreatment	Posttreatment						
		1 month	3 months	6 months	9 months	1 year	18 months	2 years
Opossum								
Brain	ND (1)	0.15 (1)		0.05 (1)			ND (1)	
Fat	ND (1)	1.72 (1)		3.35 (1)			0.55 (1)	
Liver	ND (1)	0.36 (1)		0.35 (1)			0.05 (1)	
Muscle	ND (1)	0.53 (1)		0.06 (1)			0.25 (1)	
Stomach Contents	0.03 (1)			ND (1)			0.02 (1)	
Raccoon								
Brain	ND (1)	0.13 (2)		ND (1)		ND (1)		ND (1)
Fat		2.24 (2)		ND (1)		0.31 (1)		0.06 (1)
Liver	0.07 (1)	0.25 (2)		0.03 (1)		ND (1)		ND (1)
Muscle	0.04 (1)	0.05 (2)		ND (1)		ND (1)		ND (1)
Stomach Contents	ND (1)	0.01 (2)		ND (1)				

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TABLE 9 (cont'd.). *Mirex residues in mammals from Dee Dot Ranch after single treatment of 10-5 bait, 1972–1974*

	Residues, ppm Fresh Weight[1]							
	Pretreatment	Posttreatment						
		1 month	3 months	6 months	9 months	1 year	18 months	2years
Armadillo								
Brain	ND (2)	0.20 (4)	0.17 (2)	0.01 (8)	0.10 (5)	ND (1)	ND (3)	ND (1)
Fat	ND (2)	1.10 (4)	0.47 (2)	1.68 (8)	0.08 (4)	0.67 (1)	0.52 (3)	ND (1)
Liver	ND (2)	0.59 (4)	0.13 (2)	0.24 (8)	1.21 (5)	ND (1)	0.04 (3)	0.09 (1)
Muscle	ND (2)	0.02 (4)	0.01 (2)	0.02 (8)	0.04 (5)	ND (1)	ND (3)	ND (1)
Stomach Contents	0.01 (2)	0.01 (3)		ND (8)			ND (3)	
Red Bat	ND (2)							
Evening Bat	ND (2)							
Evening Bat						ND (1)		
Evening Bat								0.09 (2)
Marsh Rabit								
Brain	ND (1)							
Liver	ND (1)							
Muscle	ND (1)							
Least Shrew				1.29 (1)				

NOTE: ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent numbers of specimens analyzed to obtain the average residues given.
[1] See footnote, Table 3.

of 0.01–3.35 ppm. In general, the highest levels were detected in fat tissues from 1 to 6 months after application. From 12 to 18 months after treatment the mirex levels decreased substantially, ranging from 0.02 to 0.67 ppm. At 24 months, the levels were low: 0.06–0.09 ppm.

Mirex levels found in birds are presented in Table 10. Sixty-two percent of the pretreatment samples contained mirex ranging from 0.01 to 0.20 ppm except for one sample which had 1.05 ppm. During the sample collection interval of 1 through 12 months after treatment, 94 percent of the birds contained mirex. The highest levels, approximately 10 ppm, were generally detected in fat tissues 1 to 6 months after mirex application. From 9 to 24 months, the pesticide levels generally decreased, reaching levels similar to those found before mirex application.

Insectivorous species such as armadillos, bluebirds, pine warblers, brown-headed nuthatches, red-bellied woodpeckers, and Bachman's sparrows showed the most dramatic accumulation of mirex. These species had lost most of their mirex burden by the 18-month collection. Omnivorous species such as crows, blue jays, raccoons, and opossums showed a less dramatic accumulation of mirex. Quail and common gallinule, which are mostly herbivorous, showed little accumulation of mirex. Carnivorous species, best represented here by the anhinga, demonstrated a surge in mirex accumulation during the middle collection period, 6 months to 1 year.

Examining the data from a broader viewpoint, one may reach some conclusions. The highest mirex levels were detected within 6 months of application. In general, insects and other invertebrates had low or nondetectable mirex levels 24 months after treatment. Crickets (Table 3), cockroaches, and earwigs (Table 4) seemed to be exceptions to this trend, still possessing detectable insecticide for the entire period, even though this occurred in a low percentage of samples. This is surprising, considering that most of these organisms were not present during bait application when the greatest amount of mirex was available. These organisms are scavengers, however, and must have been exposed to the insecticide some time after application.

The highest mirex levels were detected in birds, except for an earwig reported in Table 4. In most instances the mirex was highest in the fatty tissues rather than in the liver or stomach.

The mammals and birds consistently had a high percentage of individuals with mirex residues. This could be attributed to the fact that they are insectivors and omnivores, and to their place on the food chain and their relatively long life spans.

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TABLE 10. *Mirex residues in birds from Dee Dot Ranch after single treatment of 10-5 bait, 1972–1974*

	Residues, ppm Fresh Weight [1]							
	Pretreatment	Posttreatment						
		1 month	3 months	6 months	9 months	1 year	18 months	2 years
Anhinga (Piscivorous exclusively)								
Brain	0.03 (3)	ND (3)	ND (1)	0.03 (3)	0.06 (1)	0.88 (1)	ND (1)	0.01 (2)
Fat	0.06 (3)	ND (3)	0.47 (1)	4.98 (2)	1.90 (1)	2.25 (1)	0.03 (1)	ND (2)
Liver	0.06 (3)	ND (3)	0.11 (1)	0.18 (3)	0.23 (1)	0.55 (1)	ND (1)	0.01 (2)
Muscle	0.02 (3)	ND (3)	ND (1)	0.15 (3)	0.19 (1)	0.75 (1)	ND (1)	0.03 (2)
Stomach Content	0.01 (3)	ND (3)		ND (3)				
Red-tailed Hawk (Migratory)								
Brain	0.07 (1)	ND (1)						
Fat	0.01 (1)	0.82 (1)						
Liver	ND (1)	0.02 (1)						
Muscle	0.02 (1)	0.32 (1)						
Stomach Content		ND (1)						
Bobwhite Quail (Herbivorous)								
Brain	ND (3)	0.15 (1)		ND (2)				
Fat	ND (3)							
Liver	ND (3)	0.10 (1)		0.04 (2)				
Muscle	ND (3)	ND (1)		ND (2)				
Stomach Content	ND (3)			ND (2)				
Common Gallinule (adult)								
Brain	ND (2)	ND (2)		0.06 (1)				
Fat	ND (1)	0.29 (2)		0.02 (1)				
Liver	ND (2)	ND (2)		ND (1)				
Muscle	ND (2)	0.03 (2)		ND (1)				
Stomach Content	ND (1)	ND (2)		ND (1)				
Nestling: whole	ND (2)	0.11 (1)						
Stomach Content	ND (2)	ND (1)						
Red-Bellied Woodpecker								
Whole	ND (2)	0.21 (2)		0.12 (2)	0.23 (2)	0.11 (2)	0.01 (2)	0.02 (2)
Stomach Content	0.02 (3)	0.01 (2)		0.53 (2)			ND (2)	
Phoebe								
Whole				1.31 (2)				
Stomach Content				0.07 (2)				
Blue Jay								
Whole	ND (3)	0.20 (1)	0.17 (3)	0.10 (6)	0.05 (2)	0.06 (2)	ND (1)	0.04 (3)
Stomach Content	ND (3)	ND (1)					ND (1)	
Common Crow								
Brain		0.18 (2)	0.21 (1)	0.06 (1)	0.35 (1)	ND (1)	0.03 (1)	
Fat	0.05 (1)	0.39 (2)	10.72 (1)			0.39 (1)	0.18 (1)	
Liver	ND (1)	0.39 (2)	0.65 (1)	0.16 (1)	0.58 (1)	0.44 (1)	0.06 (1)	
Muscle	ND (1)	0.15 (2)	0.32 (1)	0.09 (1)	0.20 (1)	ND (1)	0.06 (1)	
Stomach Contents	ND (1)	0.15 (2)		0.09 (1)				
Carolina Chickadee								
Whole	ND (3)	0.20 (3)	0.18 (2)	0.11 (1)	0.09 (3)	0.12 (2)	0.03 (2)	
Stomach Content	ND (3)	ND (2)		ND (1)				
Brown-headed Nuthatch								
Whole	ND (3)	0.96 (3)	0.47 (2)	0.46 (3)	0.24 (3)	0.67 (3)	0.10 (2)	0.03 (4)
Stomach Content	0.20 (3)	0.01 (3)		0.01 (3)			ND (2)	ND (4)
House Wren								
Whole				4.05 (2)				
Stomach Content				0.55 (2)				
Robin								
Whole				0.08 (1)			ND (2)	
Stomach Content				0.05 (1)				
Hermit Thrush								
Whole				1.15 (1)				
Stomach Content				0.14 (1)				
Bluebird								
Whole	ND (3)	8.27 (1)	2.40 (1)	2.34 (2)	3.66 (3)		0.11 (3)	0.21 (2)
Stomach Content	0.01 (3)	1.31 (3)		1.36 (2)			ND (3)	

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TABLE 10 (cont'd.). *Mirex residues in birds from Dee Dot Ranch after single treatment of 10-5 bait, 1972–1974*

	Residues, ppm Fresh Weight[1]							
	Pretreatment	Posttreatment						
		1 month	3 months	6 months	9 months	1 year	18 months	2years
Pine Warbler								
Whole	ND (4)	2.57 (7)	0.45 (3)	0.49 (3)	0.19 (2)	0.05 (3)	0.01 (4)	0.02 (1)
Stomach Content	1.05 (4)	0.07 (7)		0.29 (3)				
Myrtle Warbler								
Whole				ND (1)				
Stomach Content				ND (1)				
Palm Warbler								
Whole				0.33 (1)				
Stomach Content				ND (1)				
American Redstart (Spring & Fall Migrant)								
Whole			0.81 (1)					
Stomach Content								
Red-winged Blackbird								
Whole		0.48 (2)		ND (1)	0.05 (3)	ND (1)	0.03 (2)	0.02 (5)
Stomach Content		0.02 (2)		ND (1)			0.01 (2)	
Common Grackle								
Whole	ND (3)					0.68 (2)		
Stomach Content	ND (2)			0.16 (1)				
Brain				0.12				
Fat				10.38				
Liver				0.07				
Muscle				0.14				
Rufous-sided Towee								
Whole							ND (1)	
Stomach Content							ND (1)	
Swamp Sparrow								
Whole				0.11 (2)				
Stomach Content				ND (2)				
Song Sparrow								
Whole				ND (1)				
Stomach Content				ND (1)				
Chipping Sparrow								
Whole				0.08 (2)				
Stomach Content				ND (2)				
Tree Sparrow								
Whole				0.15 (1)				
Stomach Content				0.15 (1)				
Savanna Sparrow								
Whole				ND (1)				
Stomach Content				ND (1)				
Bachman's Sparrow								
Whole	ND (4)	3.65 (5)	1.17 (3)		0.70 (8)	1.05 (3)	0.03 (3)	0.30 (3)
Stomach Content	0.03 (3)	0.25 (5)					ND (3)	

NOTE: All numbers are averages.
ND = no residues detected at 0.01 ppm level.
Figures in parentheses represent number of specimens analyzed to obtain the average residue given.
[1] See footnote, Table 3.

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APPENDIX

Chemical Names of Compounds Discussed in This Issue *

ALDRIN	Not less than 95% of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene
AROCLOR 1260	PCB, approximately 60% chlorine
BHC (Benzene Hexachloride)	1,2,3,4,5,6-Hexachlorocyclohexane (mixture of isomers)
CHLORDANE	1,2,3,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4.7-methanoindene. The technical product is a mixture of several compounds including heptachlor, chlordene, and two isomeric forms of chlordane.
CHLORDENE	4,5,6,7,8,8-hexachloro-3a,4,7,7a-tetrahydro-4,7-methano-1*H*-indene
CHLOROFORM	Trichloromethane
CHLOROPYRIFOS	*0,0*-diethyl *O*-(3,5,6-trichloro-2-pyridinyl) phosphorothioate
DDE	Dichlorodiphenyl dicholoro-ethylene (degradation product of DDT) *p,p'*-DDE: 1,1-Dichloro-2.2-bis(*p*-chlorophenyl) ethylene *o,p'*-DDE: 1,1-Dichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl)ethylene
DDT	Main component (*p,p'*-DDT): α-Bis(*p*-chlorophenyl) *β,β,β*-trychloroethane. Other isomers are possible and some are present in the commercial product. *o,p'*-DDT: [1,1,1-Trichloro-2-(*o*-chlorophenyl)-2(*p*-chlorophenyl) ethane]
DIELDRIN	Not less than 85% of 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene
HCB	Hexachlorobenzene
HEPTACHLOR EPOXIDE	1,4,5,6,7,8,8-Heptachloro 2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindan
LINDANE	*Gamma* isomer of 1,2,3,4,5,6-hexachlorocyclohexane
MIREX	Dodecachlorooctahydro-1,3,4-metheno-1H-cyclobuta[cd]pentalene
NONACHLOR	1,2,3,4,5,6,7,8-Nonachlor-3a,4,7,7a-tetrahydro-4,7-methanoindan
OXYCHLORDANE	2,3,4,5,6,6a,7,7-Octachloro-1a,1b,5,5a,6,6a-hexahydro-2,5-methano-2H-indeno(1,2-*β*)oxirene
TDE	2,2-Bis(*p*-chlorophenyl)-1,1-dichloroethane

* Compounds mentioned only by Johnson/Manske are defined in Table 1 of that paper.

Information for Contributors

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